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Army Natick Research and Development Command
Natick, Massachusetts

March 1976

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FOOD FOR THE ARMED FORCES

THIRD INTERNATIONAL MEETING
14-17 OCTOBER 1975

March 1976

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

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This is a compilation of twenty-seven presentations from nine different countries relating to the general topics of logistics and technologies of operational rations and garrison feeding as well as the nutritional and medical aspects of foods and rations.


US ARMY
NATICK
DEVELOPMENT
CENTER

COMMANDER'S WELCOME

Col. Rufus E. Lester, Jr., QMC, USA
Commander, US Army Natick Research & Development Command
Natick, MA 01760

KEYNOTE SPEAKER

Major General John C. McWhorter, Jr.
Deputy Director for Logistics (Strategic Mobility)
Office of The Joint Chiefs of Staff
Washington, D.C.

FOODS FOR THE ARMED FORCES
THIRD INTERNATIONAL MEETING

14 - 17 October 1975

US Army Natick Research & Development Command
Natick, Massachusetts

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THIRD INTERNATIONAL MEETING - FOODS FOR THE ARMED FORCES
US ARMY NATICK DEVELOPMENT CENTER - 14 OCTOBER 1975

General McWhorter, distinguished guests, ladies and gentlemen - I extend to each of you a most sincere welcome to the US Army Natick Development Center and, in turn, to this - the Third International Meeting on Food for the Armed Forces.

It is particularly gratifying to be the host nation, and to be honored by the presence of so many distinguished scientists and experts in food research. I hope your stay in the United States and at this Conference will not only be a most pleasant one, but also most fruitful.

As many of you know, coordinating such an International Conference as this, is to say the least, quite a monumental task. And I should like to recognize two of your colleagues who have made it possible. I speak, of course, of Dr. E. W. Hellendoorn of th Netherlands and our own Dr. Edward E. Anderson of the United States.

In reviewing the Agenda planned for the next few days, I am sure you will agree that the topics range through a broad spectrum of general interest and also definitive technology.

You will also note on your Agenda that arrangements have been made for you to visit some of our facilities here at the Natick Development Center. However, as your time here is limited, I thought you would be interested in viewing some of our many activities through a brief overview, following which I will introduce our keynote speaker.

The US Army Natick Development Center is devoted to improving the soldiers' effectiveness. The areas of our research development and engineering missions are reflected on this chart. You will notice that these programs are centered on the soldier and his welfare in garrison and in the field. Our overall objective is to sustain him in all environments, beginning with the battlefield.

The Development Center is located on 78 acres of land on Lake Cochituate in the town of Natick. The workforce consists of 1168 civilians and 118 military personnel. Our annual funding program is approximately 30 million dollars.

Almost all of the work we undertake in our research and development, production engineering and standardization program, is done in behalf of all military departments. Major customers include: The United States Navy, Air Force, Defense Supply Agency, and several key departments of the Army agencies.

(United States Navy, US Marine Corps, US Air Force, Defense Supply Agency, Army Research Office, Army Materials and Mechanics Research Center, Aviation Command, Medical Research and Development Command, Mobility Equipment Research and Development Center, Armament Command, and Office of the Chief of Engineers).

Over the past decade, the Center has introduced or conducted improvements on more than 1100 items. Investments of 290 million dollars during these 10 years have resulted in procurement contracts to industry in the amount of 19 billion dollars. We are responsible for the preparation of more than 2300 technical documents; the majority of which are specifications to support supply procurement.

At Natick, representatives from the four military services form a DOD Joint Technical Staff. Their role is to maintain effective liaison and coordination between their services and the Center in all phases of the Department of Defense Food Research, Development and Engineering Programs.

To accomplish our research and engineering, we have several unique and specialized facilities such as the Climatic Chambers Center Foreground. Our Arctic Chamber creates temperatures to minus 70°F, and winds to 40 MPH, and the Tropic Chamber with temperatures as high as 165°F bring world-wide environmental conditions to the Laboratory. Other examples include the Raincourt and Fire Test Facility where items of clothing and equipment can be tested: The Dye Laser System is used in study of camouflage (this is a laser beam thru a bottle of camouflage dye).

The Raman Spectrometer analyses materials such as plastics, rubber, and various composites, and computerized pattern-making machine expands Natick's clothing operations in standardizing Army clothing patterns. Our Nuclear Magnetic Resonance Spectrometer determines molecular structures of organic compounds; and our Univac 1106, a third-generation computer, assists in solving technical and management related problems.

Army volunteer test subjects are used in a variety of human related studies, both by the Center and the US Army Research Institute for Environmental Medicine, a tenant activity here. Their contributions enable us to obtain important data relating to military situations in the field, and plays an integral part in our research and development efforts.

This test subject is submerged in a water tank under controlled conditions for measuring heat transfer between his body and the water at various temperatures.

Studies include areas relative to high altitude. In this chamber, conditions up to 45,000 feet can be simulated.

Army test subjects also support mission activities of the Navy Clothing and Textile Unit, another of our tenant activities.

Now a look at our organization.

The Development Center is presently organized under a Command element, a support staff and four major laboratories. The laboratories have assigned areas of research, development or engineering, broadly indicated by their names.

This Laboratory is concerned with the creation of new, or the improvement of existing equipment, systems, and techniques for the airdrop of personnel, and material from aircraft in flight. In addition, research and development is conducted on organizational field support equipment including refrigeration, heating, printing, laundry, sanitation and tentage.

The Aero-Mechanical Engineering Laboratory is responsible for all the parachutist's equipment shown here from head to foot, and the Laboratory's mission includes research and development to support the airdrop of general equipment. This improved rigging system is one way we effectively support the military forces airdrop capability.

This survival vest for Army aviators is another example of our developments.

In the area of organizational equipment, the Laboratory's mission includes items ranging from inflatable shelters and specialized maintenance tents to items found in the Chaplain's Kit.

Natick's Food Engineering Laboratory performs research, development and engineering required to provide subsistence supporting the four military services and solve problems which arise in the daily procurement and use of these products. Research and development with freeze-dried foods produced the Long-Range Patrol Food Packet for use under non-resupply conditions. Freeze-dried foods can now be compressed and subsequently rehydrated to normal appearance and texture. The significant volume reduction can provide savings in packaging, transportation and storage.

As an example, these carrots are compressed to one fifteenth their original size. Other vegetables, such as green beans and sauerkraut, can be even more tightly compressed.

The Food Engineering Laboratory pioneered the preservation of food through the use of ionizing radiation, such as the Gamma radiations emitted from this world's largest cobalt-60 source. (You are looking down into the radiation pit - wafers of cobalt are stored in those parallel plates and exposed as the plates are raised out of the water tank.)

NASA has been the prime recipient of "Spin-Offs" stemming from our R&D efforts as far back as the dehydrated foods used on the mercury flights. Thermally processed wet meats were used extensively on Apollo menus. Apollo 17's crew ate irradiated ham processed here. We provided other technological support for the Skylab Mission, and the Apollo-Soyuz crew which took 25 of our food items with them on their recent mission.

This flexible packaging system to replace the tin can is another example of our activities; it weighs 50% less than the can; is easy to open and convenient to carry.

The Mobile Field Kitchen Trailer illustrates the latest innovation for field food service.

In the Food Sciences Laboratory, studies in the behavioral sciences are focused primarily on food acceptance in its broadest sense. This includes the testing of foods for procurement purposes and determining food preferences of military personnel.

Studies in the Life Sciences center around protection of materiel from deterioration caused by fungi and bacteria.

Ecology is another area in which Natick is working to achieve the Army's goal in Pollution Abatement. Part of this program is centered here in this model plant in which waste paper is converted into glucose sugar. This can be further processed into feed stock for the production of chemicals and plastics. This sugar can be used as a building block for the production of animal feed, fuel, plastics, solvents and chemicals. In the area of waste disposal, our scientists developed an improved treatment process to reduce the "pink water" problem at munition plants.

The Clothing, Equipment and Materials Engineering Laboratory is at work on the soldier's clothing/equipment system to provide battlefield and environmental protection. We are attempting to protect the soldier against all the hazards he may encounter - fire, chemicals, bullets, heat, cold, rain and fatigue.

This is the cold weather uniform for Army aviation crewmen. All materials used are inherently flame resistant. The helmet was developed to provide improved protection to Army aviators from noise and bumps.

Our research continues to improve body armor systems for both aircrewmen (shown here) and infantrymen. Improvements make the armor lighter and more comfortable without sacrificing protection.

Extensive work is being done to select the ideal infantryman's helmet as part of the long range body armor program.

To protect the soldier against visual detection, the Laboratory continues its experimentation with all types of camouflage patterns; they include defeating infrared detection and patterns for desert use.

Our research has determined that one pound on a soldier's feet is equivalent to six pounds on his back. Consequently, in the area of footwear, we are trying to reduce weight and improve protection. These vinyl (polyvinylchloride) overshoes are expected to undergo final testing this fall and be recommended for standardization. They weigh half as much as the standard five-buckle overshoe, cost less, and can fold into a very small package.

This lightweight insulated boot is made entirely of (micro-cellular blown) urethane, and is under exploratory development as a potential replacement for the standard item, better known as the "Mickey Mouse" boot.

Another example of the scope of our activities is in the area of arctic clothing and equipment.

Natick also developed a more comfortable, versatile load-carrying system -- incorporating a metal frame which can effectively carry a variety of loads.

This laboratory also does the engineering and development on all Army uniforms, and is the repository for all patterns and specifications including those for: The Army Blue Double Knit Uniform, the Utility Uniform in Perma Press Fabric, and the Class B Shirt, a new concept in male apparel, that can serve as a less formal every-day duty uniform.

This women's Army Green Pantsuit is now under test by women whose assigned duties make this apparel appropriate.

For the young high school miss, these are the newly created junior ROTC uniforms. In addition, the Lab is charged with engineering and development of uniforms for the Postal Service.

That, then, is a broad brush-stroke of what we do at the Natick Development Center. From parachutes to space foods; uniforms to mobile field kitchens, we are responsive to the needs of the military man and woman. We intend to remain responsive.

Thank You.

Our Keynote Speaker this morning is no stranger to research and development or to logistics.

He is a graduate of the United States Military Academy at West Point, where he was commissioned in the Quartermaster Corps in 1946. After attending both Infantry and Quartermaster Schools, our speaker went on to obtain his Master's Degree in Textile Engineering at Lowell Technological Institute, Lowell, Massachusetts.

His assignments have taken him to Okinawa, Germany, England, Vietnam, and twice to Korea. He served as an instructor, and later as Assistant Professor in the Department of Mechanics at West Point. He is a graduate of the Army's Command and General Staff College at Fort Leavenworth, Kansas, where he received the George C. Marshall Award as honor graduate, and the Industrial College for the Armed Forces at Fort McNair, Washington, D.C.

Over the years, he has served as Staff Officer in the Life Sciences Division, Office of the Army Chief of Research and Development as General Materiel and Basic Research Representative to the Army's Standardization Group in London, and as Director of Technical Operations, Supply Operations, and Planning and Management at the Defense General Support Center of the Defense Supply Agency, Richmond, Virginia.

After having served as Deputy Commanding General of the Korean Support Command and as Commanding General of the Army Logistics Command Detachment in Korea, he became Commander of this Center in July 1972. He was then reassigned as Commanding General of the Troop Support Agency at Fort Lee, Virginia, and later as Director of Transportation and Services, Office of Deputy Chief of Staff for Logistics Department of the Army. He is presently assigned as the Deputy Director for Logistics (Strategic Mobility) J-4, with the Joint Chiefs of Staff in Washington, D.C.

At this time, I would like to welcome back an old friend and former Commander of this Center, a leader, who is well-versed in military feeding, as well as logistics. It gives me great pleasure to introduce to you this morning our Keynote Speaker - Major General John Calvin McWhorter, Jr.

KEYNOTE SPEAKER

MAJOR GENERAL JOHN C. McWHORTER, JR.

THIRD INTERNATIONAL MEETING - "FOODS FOR THE ARMED FORCES"

Good morning, ladies and gentlemen. It is always a pleasure to return to Natick and renew so many old friendships.

"Food For the Armed Forces" is certainly not a modest topic. In fact, as you know, its full range could be covered only with great difficulty. However, I believe that the poet, Lord Byron, stated the issue as well as anybody when he wrote:

> "All human history attests that since Eve
> ate apples, much depends on dinner."

Fortunately, our task is somewhat more clearly defined in that our concern is with providing dinner to members of the Armed Forces - principally young men - who are sometimes stationary and sometimes highly mobile. In this context, I believe that a possible solution to the problem was suggested by Ernest Hemingway in one of his last books in which he said:

> "If you are lucky enough to have lived in Paris
> as a young man," - "Then wherever you go for
> the rest of your life, it stays with you, for
> Paris is a movable feast."

Obviously, all we would have to do is to send all of our young men to Paris, and they would be equipped with a movable feast for life. A romantic ration, indeed, but our men <u>and</u> women must have bread as well, and feeding them requires planning and attention to a host of very real factors, as your participation in this Conference so well demonstrates.

Our concerns are the perennial ones of increasing the economy and efficiency of our Food Service Operations and, at the same time, maintaining the required high nutrition and morale of our people. In this regard, I would like to compliment Colonel Lester and Dr. Anderson on planning so well the comprehensive Seminars to be held on both Operational and Garrison Rations. I do not intend to address the highly specialized subjects you will discuss during your Seminars, but rather share with you some of my thoughts on the broader area of Food Service - in the field and in garrison. Although my comments will refer chiefly to activities of the U.S. Forces, I would hope that these remarks would be of interest to the representatives of other countries by way of analogy or example.

The term "Operational Ration" immediately brings to my mind the basic purpose of food for the Armed Forces - and that is to insure that the combat soldier who arrives at, captures, and secures an objective area, is well fed and possesses the staying power to repel a counterattack or to continue the advance. I recall many combat stories sprinkled through history in which half-starved armies halted their advance in order to feed upon captured supply dumps - only to be overrun by counterattacks. The defeated troops lacked staying power.

Other excerpts from the history of operational rations feature armies which subsisted on the horses used to haul their artillery and supply wagons. The modern armies of today no longer have that option. Stories of World War II and the Korean War are replete with the extended feeding of canned spam and of frozen Thanksgiving turkeys being blown up during the long retreat from the Yalu. The Vietnam food service saga is unusual. Never has an army in the field been so well fed and logistically pampered in a combat zone. Use of helicopters to fly in paper plates, plastic knives, forks, and spoons, and hot meals with ice cream for dessert did occur with regularity. The ability to provide this level of service is very doubtful in future conflicts.

What, then, lies ahead for operational rations? I feel there is only one certainty. That is the requirement. The field commander, the logistics planner, the transporter - all agree on the requirement. They would like a completely nutritious ration that weighs practically nothing, takes up no space, and has an indefinite storage life under all temperature conditions. I venture to guess that if each of you asked your user to describe the ideal operational ration, most would describe a capsule that would satisfy all nutritional and taste requirements. The need for lighter and smaller rations is not new. However, the increased sophistication of our armies today makes these factors more important than ever. The weight carrying capacity of the individual soldier has not increased, but just look at what modern technology has added to his burden. Hand-held anti-aircraft and anti-tank weapons, faster firing weapons which add to his ammunition load, body armor, and other protective equipment. You might counter that today's soldier travels in tanks, trucks, armored personnel carriers, and helicopters so that the extra weight isn't that important. But, in the objective area, our soldiers must still dismount and fight on foot, and, at that point, weight is critical to his performance. How ironical that when a soldier decides what he will carry into combat, he often discards portions of your carefully designed rations which would allow him to perform at maximum efficiency.

While you who are in the business can explain to our users why a capsule ration is not technically feasible, I am encouraged by recent developments that show we are gaining on the problem of reducing weight and volume in our operational rations. The reduced size and weight of the long range patrol ration developed for use in Vietnam was a major step forward. The new meal, ready-to-eat in flexible, individual packages finally releases us from the weight and bulk of metal containers. And, of course, following right behind are the reversibly compressed freeze-dried foods which offer even greater potential reduction in weight and cube. So, we are making significant progress in meeting the users' requirements. This serves not only as a major benefit to the soldier on the battlefield, but has a domino effect throughout the entire logistics network from brigade forward support area to in-theater storage areas to intra- and intertheater movement requirements and theater stockpile needs. As an example of transportation savings, let's consider airlift requirements. The airlift required to move to Europe enough operational rations to feed one division for one month would require 60 C-141 sorties. The savings of any significant portion of this requirement indicates the utility and economy of these new rations.

Closely associated with operational rations is the subject of field food service. For years the US Army provided only a kitchen tent into which our field cooking equipment was placed. It is a tribute to the ability of our cooks that they were able to turn out good food. Innovative soldiers rigged up kitchen trucks, some of which were effective - some were not. We now have in the final stages of development the mobile field kitchen trailer which, for the first time, gives us a standard, highly mobile field kitchen which can keep pace with our units on the move. This trailer uses standard field cooking components. It is simple and effective and is hailed by our cooks in units in the field as an outstanding piece of equipment. Interestingly enough, before we arrived at this relatively simple, rugged trailer, we worked on two highly sophisticated kitchen trailers using modern state-of-the-art cooking equipment. The net result was that the sophisticated unit took too much power, too much training to use and maintain, cost too much, and wouldn't withstand the rough usage in the field. We relearned a basic lesson - that equipment for use in the field must be rugged and simple to use and maintain. So, we have finally made the transition from a "put up the tent" to a "park and cook" routine allowing our cooks to be more responsive to our mobile forces.

Without doubt, in peacetime, garrison food service is probably our biggest job when we speak of food for the Armed Forces. For the U.S. Armed Services, the advent of our volunteer forces, as opposed to a draft based force, has seen significant changes in our concept of garrison food service. My first experience with food service in support of a volunteer army was in the United Kingdom in 1964. I had the pleasure of visiting the home of The Royal Catering Corps in Aldershot and to see their main dining facility. I was amazed at what I saw: tasteful decor, separate cold and hot serving lines, food service personnel in attractive uniforms, multiple entrees, salads, and desserts. Little did I realize then that just a few years later, the U.S. Army would be going the same route and for the same reason - if you are going to get your soldiers to reenlist, they must have positive thoughts about the food they are furnished and the dining facility they eat in. As we moved into our modern food service program, we had another problem, the soldier we were catering to had grown up on hamburgers, hot dogs, french fries, milk shakes, and soft drinks. He or she didn't eat a breakfast as we know it. So, our new program included short order lines with hamburgers, hot dogs, and french fries. Our full meals offered multiple meat and other entrees. Carbonated beverages and soft ice cream were made available. Specialty houses were opened that provided pizza, fried chicken, and shrimp. Continental style breakfasts were added. All of this in our old, dingy dining facilities still lacked something, so we embarked on a program to renovate our dining facilities - put in modern cooking equipment, serving lines, salad and dessert bars, upgraded the decor so our soldiers could be proud of their facility. The program is well underway and it is working. The point I am making here is that it isn't enough to provide balanced nutritious meals, well prepared. We had that before, but no one was coming to eat because it wasn't what the soldiers wanted and they didn't like the environment in which they ate.

Let me, in closing, make a final reflection upon our reasons for being here today. We all recognize, I am sure, that these exchanges on food for our forces are building blocks in the structure we are erecting to insure our mutual security and world peace. Our need to improve our capabilities is unrelenting. One of the most promising areas for progress is that of standardization! Currently, NATO standardization is receiving a lot of attention in the Pentagon, and, although I fully realize that all national eating habits and tastes differ and that standardization of food might be unrealistic and perhaps undesirable, increased familiarity with the food of other NATO countries would, I feel, benefit each of us. A heightened mutual appreciation of this key cultural component might well act as a sort of psychological catalyst in our efforts to increase standardization in other areas so vital to our security posture. I personally feel that there is the possibility of standardization in some special-purpose operational rations, and the sharing of some of our food processing techniques could be beneficial.

What we must constantly bear in mind is that the importance of food service is taken for granted until a problem arises. These problems can generate in single units or in a whole system. It is up to you to help keep the emphasis on the program, to foresee potential problems, alert decisionmakers, and provide solutions.

I know from past experience that you will have a productive Seminar. Hopefully, seeing what others are doing will generate a spark of an idea to a new approach towards solving some of our common problems. It has been a sincere pleasure for me to be here with you, and I am looking forward to trying some of the operational rations at lunch today. Thank you very much.

SESSION I -- NUTRITION

Chairman: Colonel John E. Canham, MC, USA
Director, Letterman Army Institute of Research
San Francisco, California

Food Purchased Food Consumed -- The Wastage Gap	Lt. Col. D. E. Worsley, RAMC U.K.
The Nutritive Value & The Effects of Storage on Operational Rations	Col. H. H. Sass Denmark

Chairman: Major Eleanor M. Coulter
National Defence Hqs
Ottawa, Canada

Water, The Essential Element in the Diet	Dr. Ralph F. Goldman U.S.A.
Nutritional Requirements of German Servicemen	Dr. Erich Sommer W. Germany
Amounts & Nutritional Adequacy of Foods Consumed Outside of Military Dining Facilities	Dr. Terrel M. Hill U.S.A.

Chairman: Dr. H. E. Sauberlich
Chief, Department of Nutrition
Letterman Army Institute of Research
San Francisco, California

Application of Nutritional Principles to British Army Ration Pack	Col. D. E. Worsley, RAMC U.K.
Energy Intake and Energy Expenditure of a Group of 20-30 Year Old Dutch Navy Personnel in Training for Non-Commissioned Officer	Dr. J. Zaal The Netherlands and Dr. E. Hillert W. Germany

SESSION I -- NUTRITION (Cont'd)

The Impact of Low Caloric Feeding During Exercise	Mr. C. F. Consolazio U.S.A.
Establishment & Aasessment of Certain US Military Nutrient Requirements	Dr. H. E. Sauberlich and Col. J. E. Canham U.S.A.

Guest Speaker: Dr. Jean Mayer
Professor of Nutrition
Harvard University
Boston, MA

Subject: The World Food Situation

FOOD PURCHASED, FOOD CONSUMED - THE WASTAGE GAP

Major C M French RAMC
Army Personnel Research Establishment

INTRODUCTION

1.1 Since the Second World War there have been many changes in the eating habits of the aoldier and in the catering methods of the Army.

1.2 Little was known of the exact food intake of the soldier in barracks, and its relationship to the supplies purchased and a atudy was set up to investigate some aspects of this problem. The first requirement was to determine the wastage occurring between purchase and consumption of food, for many years assumed in the Army to be some 10%, although this figure is lower than that accepted by many civilian catering organisations. The second requirement was to discover something of the quantity and quality of the resulting food intake of the soldier, including observations on the food intake derived from non-military sources.

1.3 This paper describes a survey carried out with particular emphasis on the wastage gap, which is of logistic, financial and perhaps nutritional importance, Part I, in addition findings related to individual eating habits are reported, Part II.

UNIT SURVEY

PART I

METHODS

2.1 A team of four, one Physiologist and three cooks was assembled at APRE and between June 1972 and May 1973 visited 20 Units, in England, Scotland, Northern Ireland and BAOR.

2.2 The study was confined to Army dining rooms where the food consumed over a period was measured. In the case of the 10 units in England, 2 in Scotland and 3 in BAOR the period was 7 consecutive days to allow for differences between various days of the week. In Northern Ireland each of the 5 units was studied for 4 consecutive days, this shorter period being enforced because of the security situation at the time. However since the daily routine of these units was fairly constant, not being affected by weekends, this shortening of the study had very little effect on the results. Of the units studied 1 was composed entirely of boy soldiers, 2 of recruits of which one was 50% boy soldiers, and three units served approximately 33% women.

2.3 The total daily feeding entitlement of the 20 units involved 4713 men, equivalent to 30348 man/days. "Entitlement" throughout this report refers to the number of men for whom the caterers receive money and are therefore obliged to provide with food.

Raw Materials

3.1. At each cookhouse a complete stock check was made immediately before the investigation started. This included not only food in store but food in the course of preparation, food recovered from previous meals, fat in friers and any other edible items in the cookhouse. During the study an accurate record of all food entering or leaving the cookhouse for any reason was maintained. This included items given to the cookhouse from Unit gardens or other sources. Immediately after the last meal the stock check was repeated. Then by adding the total input to the first stock estimate and deducting any output and the second stock estimate, the quantity of raw material used during the period of the study was calculated. This was then converted to the energy equivalent of the edible matter using Food Value tables. The preparation of Food Value Tables and the method of allowing for edible wastage, are described later.

Inedible Material

4.1 The dust bins used in the cookhouse were lined with plastic bags and any inedible material such as potato peelings produced during the preparation of the food was collected in them and later weighed.

4.2 Inedible materials such as meat bones left at the end of the meal were also collected and weighed.

4.3 Vegetable peelings, fruit skins, animal and fish skins, and bone were classed as inedible with the exception of bones used for the purpose of preparing stock. Proportions of those inedible waste figures were used as a basis for amending the food value tables to give values for edible food at all stages of preparation in the cookhouse. This allows comparison between units regardless of the quantities of prepared convenience foods used.

4.4 Items such as meat fat which could be recovered for use in cooking or in the preparation of other dishes were considered edible whether or not this recovery took place. Also any edible food lost through spoilage in store or during cooking was regarded as edible, even though it could not be eaten.

Food Served

5.1 All food made available to the soldier was measured under this heading whether it was provided from the servery, or placed on the tables or elsewhere in the dining room. Any food provided by the cookhouse (such as haversack meals, snacks for sports or other events and any additional items like guards night meals) even though it was not eaten in the dining room was also included.

5.2 As the food was produced for serving it was weighed and after the meal the quantity left was weighed. All weights were corrected to allow for the containers.

5.3 The food remaining ("left-overs") was divided into two categories:-

a. That which was prepared and used again in any form.

b. That which was disposed of as swill and this was called "Servery Waste".

5.4 The quantity of food taken at any given time could then be calculated as the difference between the quantity made available and the quantity of the "Left overs". As in other situations this was converted into terms of energy equivalent of edible matter using the Food Value tables.

Plate Waste

6.1 After each meal all plates and other utensils used on the tables were collected and all the food left on these was divided into its constituent parts, ie. meat of various types, different vegetables, inedible bone etc.

6.2 Where separation was not possible, such as with mash potatoes and gravy, the proportion of each in the quantity left was assumed to be the same as the relative proportion taken from the servery.

6.3 The plate waste was then weighed and expressed in terms of the energy value of the edible matter of the individual items.

6.4 In the case of haversack rations and other items eaten away from the unit where no estimate was available of the plate waste this was considered to be zero. However these items were then classified in a separate category headed "others" and not included with food taken in the cookhouse where exact estimates of plate waste were available. When this required an alteration in the feeding entitlement of the appropriate meal, this was made.

Food Eaten

7.1 The energy equivalent and composition of the food eaten was calculated from the difference between the food taken and the plate waste.

Classification of Meals

8.1 Meals taken in the cookhouse were classed as Breakfast, Lunch, (or Mid-Day) and Dinner (or evening) depending on the time of day. Brunch meals were considered as either Lunch or Dinner depending on the time of the day they were served. A second method was also used relating to the content of the meal classing it as Breakfast, Main meal, Other meal regardless of the time when these were taken. Units varied as to whether the Main meal was Lunch or Dinner. The term "others" was reserved for items provided by the cookhouse but eaten elsewhere eg guards night suppers taken off to the guard room for consumption, or haversack rations. As no record of plate loss could be made in such cases, this was assumed to be nil. The food value of the items was noted at the time of issue.

Entitlement and Attendance

9.1 The entitlement for each meal was taken from the units nominal roll adding any casual visitors or entitled civilians or married personnel on duty eg guards eating at that meal. Any entitled personnel who received packed meals or had other alternative eating arrangements made were deducted since these meals would appear under the title of "others", as previously stated.

9.2 The attendance at each meal was obtained by counting the number of people taking a meal or part of a meal. Providing some item, even a cup of tea was taken during a meal the person taking it was counted as an attender, entry into the dining room without taking anything was not counted as attendance.

Estimation of the Energy Value of Food

10.1 Estimates of the nutritive values of foods in two forms, (1) "as supplied" and (2) "as served" after cooking, were made using the basic data given in the Army's "Nutritive Value of Foods" and the Medical Research Council's "The Composition of Foods". Additionally, it was necessary to analyse about 180 composite cooked dishes to complete the estimates on the "as served" basis.

10.2 The energy value of the food was calculated from the weight (in grams (g)) of protein, fat, carbohydrate and alcohol using accepted conversion factors of 17, 37, 16 and 29 kJ respectively for these nutrients.

10.3 For convenience, a special Food Composition Table was prepared for this study so that the appropriate factors could be applied directly to the weights of food as recorded in the "as supplied" state including bones, skins and other inedible parts or the "as served" state where the food is usually all edible except for some bones in flesh foods, shells on boiled eggs and skins on fruit and vegetables.

Terms used in the Analysis of Results from Cookhouses

11.1 The passage of food from the raw material to that eaten is shown diagramatically in Fig 1. The raw material may have been partially or completely processed before purchase with a "Treatment Loss". As this occurred before purchase it was not included in this survey.

11.2 After purchase further processing might occur, which resulted in the removal of inedible portions and a loss of edible nutrients either by trimming or during cooking,this loss of edible matter was termed "Preparation Loss". In this study it is represented by the difference between the items used as measured through the stores checks and stores input and output records, and the quantity of food served measured by direct weighing. The food going to the "Servery" was either taken onto the "Plate" or remained on the servery. In the latter case it could either be recovered as "Left Overs" which were used again as such or reprocessed, or it could be lost as swill termed "Servery Loss". As at other stages only edible matter was included in these measurements.

11.3 The food taken on the "Plate" would either be left as "Plate Loss" which was subdivided and weighed or "Eaten" which was estimated as the difference between edible food taken and the edible "Plate Loss".

11.4 The total loss during the passage through the cookhouse ie. "Preparation Loss" plus "Servery Loss" plus "Plate Loss" is referred to as the "Gap". (Fig 1.)

Food Composition

12.1 The energy values of simple foods were calculated from their recipies using food value tables. This technique was validated by testing the predicted values for twenty dishes, against the result of their analysis. A good agreement between results was found.

12.2 The composition of more complex dishes was obtained by analysis.

RESULTS

The "Gap"

13.1 Food equivalent to 358,000 MJ was supplied to the 15 units in UKLF and BAOR during the study. Of this total 232,00 MJ were eaten and 126,000 MJ were not eaten. The loss of edible food (the Gap) is thus shown to be 35.2% of that supplied. Table 1 shows the breakdown of this into overall Preparation Loss, Servery Loss, and Plate Loss. These estimates exclude the 5 units in Northern Ireland. (See Fig. 1A).

Use of Subtotals

14.1 The Servery Loss, Plate Loss, and Left Overs for individual items cannot be referred back to the Material Used since it was not possible to determine the proportions of the Raw Material going to each dish. For example though the quantity of raw potatoes used would be known the relative proportions of this going into Chip Potatoes, Creamed Potatoes, Roast Potatoes, etc served at the meal was not measured because of the small size of the survey team and the large inconveuience this would have caused the cookhouse.

14.2 The Servery Loss, Plate Loss, and Left Overs can be expressed as percentages at the Servery or on the Plate.

14.3 Therefore the various percentages have been calculated as follows:-

$$\text{Preparation Loss \%} = \frac{(\text{Raw Material} - \text{Cooked Food}) \times 100}{\text{Raw Material}} \%$$

$$\text{Servery Loss \%} = \frac{(\text{Served Food} - \text{Food Taken} - \text{Left Overs}) \times 100}{\text{Served Food}} \%$$

(Note: The Served Food could be greater than the Raw Material as it might include Left Overs from previous meals).

$$\text{Recovered \%} = \frac{\text{Left Overs}}{\text{Served Food}} \times 100\%$$

$$\text{Plate Waste \%} = \frac{\text{Plate Waste}}{\text{Food taken from Servery}} \times 100\%$$

$$\text{Food Eaten \%} = \frac{\text{Food Eaten}}{\text{Food Cooked}} \times 100\%$$

(Note: In the last case the Food Eaten was adjusted to allow for Left Overs eaten at other times. Thus the difference between this value and 100% shows the quantity actually lost as swill and never eaten (excluding the "Preparation Loss").

14.4. These definitions also present a fairer idea of the proportions of each item lost at a particular stage since they refer only to that stage. Table 2 shows the result of recalculating the figures in Table 1 according to the above definitions. The Servery Loss is less, due to the fact that it is referred to that from Raw Material and Left Overs, while the Plate Loss is greater, because it is referred to the quantity actually going onto the plate which is the Raw Material less the Preparation Loss and Servery Loss.

Variation between Units

15.1 The results in Table 1 and Table 2 refer to the total quantity of food consumed in all 15 units studied outside Northern Ireland. As large units will have a greater effect on these results than small units these results may be unfairly biased, however, when compared with other methods of presentation of the same observations, Table 3, no remarkable change is found.

Variation of Components of Foods

16.1 The food has been divided into carbohydrate, fat and protein, which has been subdivided into animal and vegetable. The breakdown for the total food consumed, excluding units in Northern Ireland, as in Table 2, is shown in Table 4.

Total Daily Food Intake per Man

17.1 Close estimation of Intake per man proved impossible with the facilities available, as attendance was recorded in total numbers and not by names.

17.2 A "minimum" figure was obtained by dividing the total food consumed by the entitlement.

17.3 A "maximum" figure was obtained by dividing the food consumed by an "average" attendance.

17.4 These figures span the range in which the true average food intake per man must lie, and are presented as Table 5.

Relationship between Food Intake and Activity

18.1 In only one unit, the Military Corrective Training Centre (MCTC), was it possible to investigate this aspect. In this unit only food provided by the cookhouse was allowed and so exact estimation of Food Intake was possible. Activity was also strictly controlled, all personnel carrying out the same activities for the same lengths of time, and when not officially controlled little activity was permitted due to the restrictions. Hence there was little opportunity for large variations in energy expenditure between individuals.

18.2 Table 6 sets out the weekly activity. This was used to estimate the mean daily energy expenditure of 16.9 MJ per man by reference to a number of standard tables.

18.3 The energy equivalent of the food actually eaten was between 16.8 MJ and 17.0 MJ per man per day.

PART II INDIVIDUAL SURVEY

METHODS

19.1 In order to relate the quantity of food eaten in the dining room to that purchased outside a number of individuals were selected and studied in more detail.

19.2 Selection was made the day before the study started by the random numbering of seats and the selection of the person nearest a given number at set time intervals during the meal. This method is a simple way to obtain a representative cross-section of those eating in each unit.

19.3 These individuals were instructed to use numbered coloured plates and provided with their own supply of sugar, butter, margarine, jam as appropriate. Each item taken was weighed before the next item was taken and thus a complete list of items and the quantities taken from the cookhouse at each meal was obtained. After the meal the plates were collected separately and the plate waste of each item measured.

19.4 Each individual was issued with a seven day diary in which he or she recorded meals, snacks, beverages both alcoholic and non-alcoholic purchased or obtained from any source other than the cookhouse during each day.

19.5 All quantities were converted to the energy equivalent of the edible matter, expressed in Megajoules (1 Megajoule (MJ = 239 Kcal).

RESULTS

20.1 The 120 selected individuals were reduced to 105 due to 15 individuals 1 leaving the units for various ressons such as leave, posting and ill-health during the survey. This number contained members of 14 units in England, Scotland and BAOR. Members of MCTC are treated separately as they lacked the freedom of choice possessed by the other units. Individuals were not studied in Northern Ireland because of difficulties raised by the security situation.

20.2 The number is too small to allow consideration by units and all individuals have been included in a single group.

Attendance Rates

21.1 The attendance of the "Individuals" sample was typical of habits in the units participating (Table 7.)

21.2 The number of meals taken outside the dining room was estimated from the diaries kept by the subjects. There is an inverse relationship between meals taken in the dining room and meals taken elsewhere. Two subjects took no meals at all in the cookhouse but did admit to eating adequate amounts elsewhere.

Plate Loss

22.1 The proportion of food taken by the subjects in the dining room could also be compared with that for the whole dining room. Table 8 shows this comparison. The mean Plate Loss for the individuals was about the same as that overall.

22.2 The variation between subjects was very large, virtually 0 to 45%, but each subject was very consistent, some leaving very little, others a lot. Where a significant amount was left this involved all items taken equally.

Meal Size

23.1 The mean size of the meals taken by the 105 subjects when .ttending the dining room is compared with that calculated from the total food eaten and total attendance at the same meals in the same 14 units, in Table 9. The individual subjects appear to have taken slightly smaller meals, perhaps due to the fact that they had been singled-out for study.

Daily Food Intake

24.1 The food intake of each of the 105 individual subjects is summarised in Table 10 and Table 11.

24.2 The individuals took 46% of their food intake in the dining room and purchased 54% elsewhere. When energy intake from alcohol is included the proportion taken in the dining room is 38% of the total.

24.3 The 105 individual subjects could have had a possible 2128 meals in the dining room. On each occasion whether they attended or not they were asked whether the cookhouse food was sufficient in quantity and adequate in quality. 84% of the replies said it was, the reasons for non-attendance being unrelated to the food itself.

Portion Size

25.1 All the 14 normal dining rooms allowed self service and second portions. These were compared by weight with those served in the Military Corrective Training Centre and there was no significant difference.

Effect of Breakfast

26.1 The daily energy intake of the 20 subjects with highest breakfast attendance was compared with that of the 20 subjects with lowest breakfast attendance in Table 12. The difference indicates that eating a breakfast is an addition to the total days intake for non breakfast eaters.

DISCUSSION

27.1 The number of units studied is comparatively small, but comprises about 5% of the total entitlement. Therefore it is very unlikely that all of these units would lie at the extremes, and it can be assumed that they present a fair representation of the whole. The large units have a greater effect on the overall figures but when units are treated separately this effect is removed. The range between both units and individuals is large and in many cases the distribution is somewhat skew so the median may be preferable to the mean as an index of the whole sample. There is, in fact, very little to choose between these possibilities, as is seen in Table 3 where they are compared.

Food Intake

28.1 In all units except the Military Corrective Training Centre this was unrestricted. However both units attendance rates and individual attendance and food intake indicate that only about 50% of the entitlement is taken. That there was sufficient food to meet the demand and provide a continuing choice throughout the meal is indicated by the fact that there was a servery loss or left-overs for almost every item at every meal.

28.2 The "individual subjects" allow an estimate of the actual total energy intake though this figure is subject to imprecision in the diary technique used to estimate the quantity taken outside the dining room. The mean of 13.73 MJ per man per day is remarkably close to the maximal possible for those attending the dining room, 14.7 MJ per Man per Day (Table 5). This, however, would be in accord with the principle that when food was not eaten in the dining room it was eaten elsewhere, in which case the sume of three meals in the dining room would equal the sum of three meals taken by an individual regardless of the eating place.

28.3 It is therefore reasonable to conclude that the daily energy intake is of the order of 13MJ to 15MJ per Man per Day, even though only 8MJ to 9MJ is actually provided by the cookhouse (see Table 5 calculation by entitlement). This is of the order of 60% which is similar to the attendance rates (Table 13). The individuals results would suggest that it is less, about 50%, but then the individuals took smaller meals in the dining room (Table 9). This may have been a result of the disturbance caused by the study.

28.4 Even with free choise and outside purchase the balance of the food intake was satisfactory (Tables 5 and 10).

Food Preference

29.1 Little information is available regarding this, all cookhouses, however, produced dishes said to be locally popular. These were simple in the recruit units, becoming more exotic the more varied the experience of the unit.

29.2 Plate waste cannot be used as an index of the non-popularity of foods. Whilst the amount of plate waste varied from person to person, each individual consistently left similar amounts of foods at successive meals. Such wastage was as true of foods the individual liked as much as those he disliked.

29.3 The items providing the greater proportions of the energy are a better guide, but here it could be argued that the cookhouse could be encouraging this selection. However chips are without doubt universally popular, as are potatoes in any form. Eggs, fried or scrambled, sausages and milk are all popular and show low loss rates. Beef in several forms is the preferred meat. Bread and sugar are eaten in fair quantities and particularly in the case of sugar the quantity increased with greater amounts of physical activity.

The "Gap"

30.1 The Median is probably the most useful indicator of the value that a unit might be expected to obtain. In the case of the 15 Units in UKLF and BAOR this was seen to be 32%. (Table 3). This is very much larger than the traditional allowance of 10%.

30.2 While Servery Loss and Plate Loss varied between units this variation did not have any apparent relation to the type of unit or catering methods. The loss was also of less significance than that occurring as Preparation Loss (Table 1). Preparation Loss was therefore considered separately.

30.3 The Preparation Loss accounted for over 60% of the "Gap" and showed a greater variability between units than other losses. It showed a direct relationship to the type of catering. Table 14 shows the difference between the Military Corrective Training Centre, with fixed attendance and controlled portions, 5 Units in Group Catering Aldershot, with centralised purchase and preparation, and 9 other Units in England, Scotland and BAOR. The decrease occurring with increasing control by the caterer is highly significant.

CONCLUSIONS

31.7 It is therefore concluded that an overall loss of 32% of edible matter occurs between purchase and eating. In certain special circumstances, where special catering methods can be used, it may be reduced. The lowest value recorded was 18.7% and it is felt that this represents the minimum possible. This is not possible where a free choice and a help-yourself system is allowed. In this situation the probable minimal value which could be obtained in facourable circumstances may be of the order of 20%

31.2 The daily energy intake was between 13MJ and 15MJ with a satisfactory protein content.

31.3 About 40% of the daily energy intake came from sources outside the cookhouse.

31.4 The "Gap" was about 32%, of which about 2/3 was accounted for by "Preparation Waste". The "Gap" could be slightly reduced by tighter catering controls, but even in very special circumstances would not go below 20%.

31.5 The uptake of meals was about 60% and it was the 40% missed meals which made it possible for the caterer to provide the requirement in spite of the larger-than-anticipated "Gap".

31.6 If for any reason the attendance rate is increased, catering standards must fall unless an appropriate allowance is made.

Fig. 1. Diagramatic Representation of the Passage of Edible Matter from Raw Material to point of Eating.

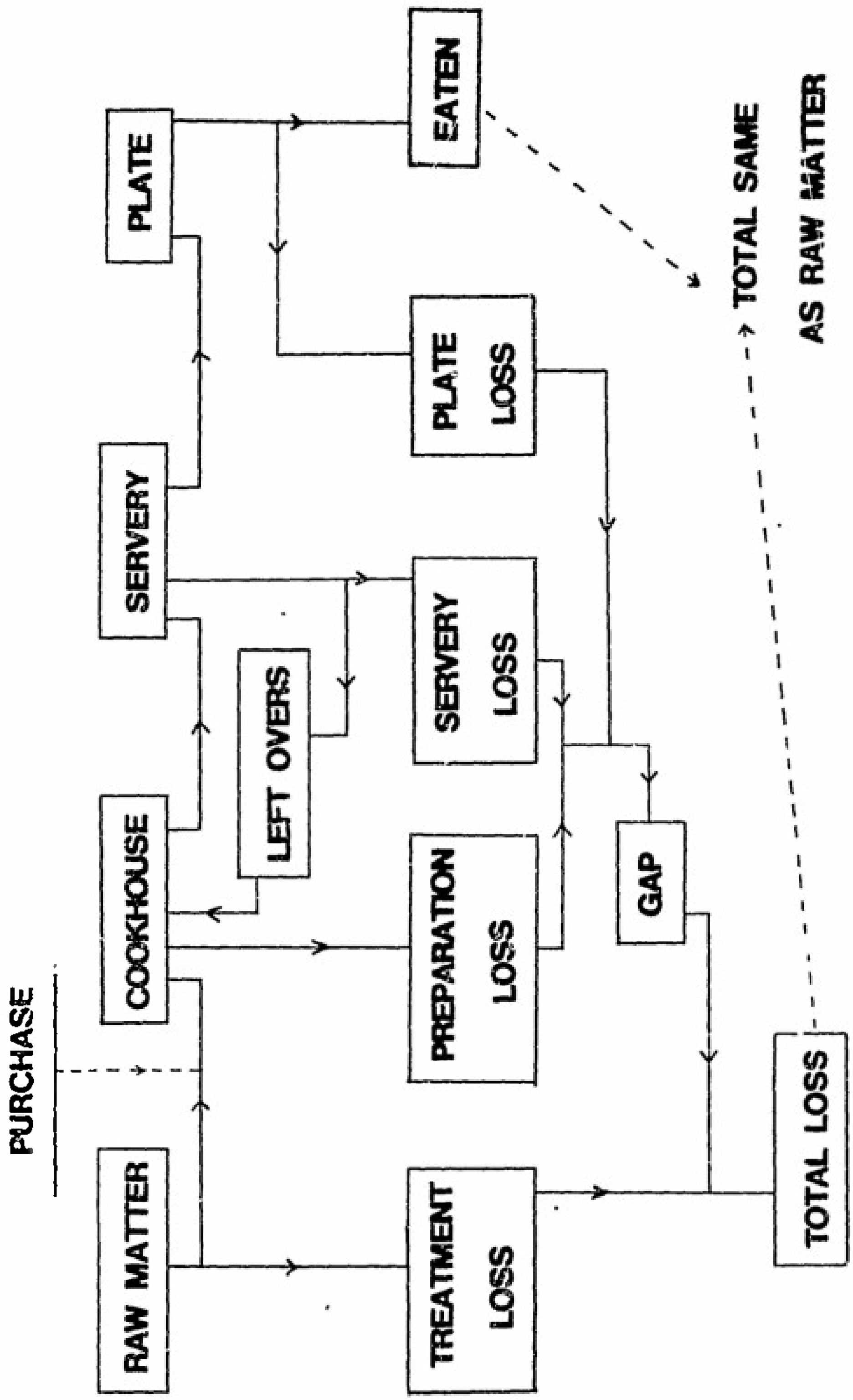

FIG.1[A]. LOSSES OF EDIBLE MATTER AS A PERCENTAGE OF FOOD PURCHASED.

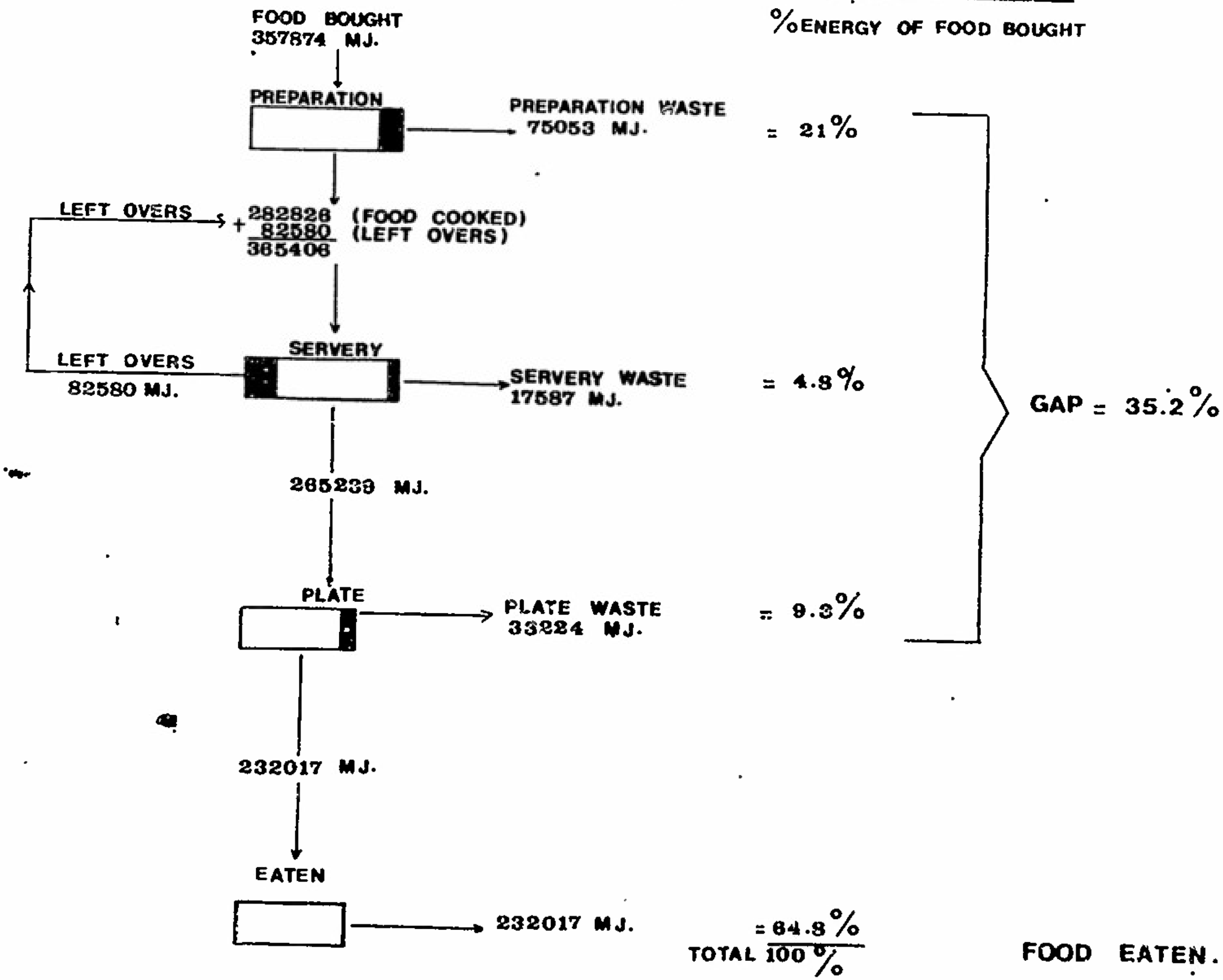

TABLE 1 LOSSES DURING PROCESSINF OF FOOD AS % OF THE AVAILABLE ENERGY OF THE MATERIAL USED, FOR 15 UNITS IN ENGLAND, SCOTLAND AND BAOR.

Preparation Loss	Servery Loss	Plate Loss	Total "Gap"
21.0	4.9	9.3	35.2

TABLE 2 LOSS OF AVAILABLE ENERGY OF EDIBLE MATTER DURING PROCESSING OF FOOD.
RECALCULATION OF THE RESULTS IN TABLE 1 USING THE METHODS DESCRIBED UNDER HEADING "USE OF SUB TOTALS"

Preparation Loss %	Servery % Loss	Plate Loss %	Total "Gap" %	Food Eaten as % of Food Cooked
21.0	4.8	12.5	35.2	82.0

TABLE 3 THE LOSSES OF EDIBLE MATTER DURING THE PROCESSING OF FOOD. THE SAME RESULTS AS IN TABLE 1 AND 2 BUT USING DIFFERENT FORMS OF PRESENTATION.

Presentation	Preparation Loss % *	Servery Loss %	Plate Loss %	Total "Gap" %	Food Eaten as % of Food Cooked
Calculated from total food in 15 Units.	21.0	4.8	12.5	35.2	82.0
Calculated for each Unit Mean of 15 Units	20.0	6.1	11.9	34.4	81.4
Calculated for each Unit Median of 15 Units	17.0	4.5	12.0	32.0	82.2
Calculated for each Unit Range of 15 Units	5.4-44.4	2.6-12.7	5.4-16.1	18.7-57.4	76.6-86.6

* See section on "Use of Sub totals"for definition of Column headings.

TABLE 4 BREAKDOWN INTO THE CONSTITUENTS OF THE EDIBLE MATTER ~~ THE FOOD, FOR UNITS OUTSIDE NORTHERN IRELAND (. the results presented in Table 2).

	Preparation Loss %	Servery Loss %	Plate Loss %	Total "Gap" %
Animal Protein	3.1	5.6	15.1	23.4
Vegetable Protein	31.2	4.9	13.1	44.0
Total Protein	14.9	5.3	14.4	32.0
Fat	20.9	5.7	13.0	36.0
Carbohydrate	22.6	4.0	11.6	35.3
Total	21.0	4.8	12.5	35.2

TABLE 5. DAILY FOOD INTAKE IN THE DINING ROOM. THE VALUES DO NOT REPRESENT THE ACTUAL VALUE BUT SET THE LIMITS WITHIN WHICH THIS MUST LIE, SEE UNDER HEADING "TOTAL DAILY FOOD INTAKE IN DINING ROOM" FOR DETAILS. MJ PER MAN PER DAY.

	Percentage of Total		Maximum possible calculated using "average" Attendance		Minimum possible calculated using Entitlement	
	Elsewhere	Northern Ireland	Elsewhere	Northern Ireland	Elsewhere	Northern Ireland
Protein (65% animal)	14	15	2.1	2.0	1.2	1.3
Fat	39	42	5.7	5.8	3.3	3.4
Carbohydrate	47	42	7.0	5.8	4.1	3.4
Total			14.7	13.7	8.6	8.0

TABLE 6 ACTIVITY PER MAN PER WEEK OF PERSONNEL AT THE MILITARY CORRECTIVE TRAINING CENTRE.

ENERGY EXPENDITURE

ACTIVITY	mins/week	Energy expenditure MJ/min	Total Energy MJ/week
Sleep	3360	.0046	15.5
Dressing/washing/etc	210	.0146	3.1
Breakfast	210	.0105	2.2
Lunch	420	.0105	4.4
Tea	210	.0105	2.2
Sitting/Education/Talks/ etc.	1720	.0084	14.4
Active sitting/shooting	800	.0103	8.2
Fatigues	210	.0071	1.5
Drill/Marching	360	.0293	10.5
PT/Assault Course/Sport	840	.0372	31.2
Hard Running /PT	280	.0439	12.3
Kit Cleaning	420	.0107	4.5
Relaxation/TV/Films	1040	.0083	8.6
TOTAL	10080		118.8

Daily Expenditure = 16.9 MJ

TABLE 7. ATTENDANCE RATE AS % OF POSSIBLE ATTENDANCES FOR INDIVIDUALS COMPARED TO THAT OF THE UNITS.

	Breakfast	Midday	Evening
Individuals	41	59	61
Units	45	64	62

TABLE 8. PLATE LOSS AS % OF QUANTITY TAKEN ON TO PLATE. MEAN FOR 105 SUBJECTS COMPARED WITH TOTAL FOR THE SAME 14 UNITS.

	Protein	Fat	Carbohydrate
Mean of 105 Subjects	14	14	10
Total of 14 Units	15	13	12

TABLE 9. MEAL SIZE: MEAN OF MEALS TAKEN IN DINING ROOM BY 105 INDIVIDUAL SUBJECTS COMPARED WITH THE AVERAGE MEAL SIZE CALCULATED FROM TOTAL FOOD TAKEN AND TOTAL ATTENDANCE IN THE SAME 14 UNITS. MJ PER MAN PER MEAL.

	Breakfast	Lunch (Midday)	Dinner (Evening)
Mean of 105 Subjects	2.66	3.45	3.86
Average for 14 Units	3.53	4.42	4.58

TABLE 10. DAILY ENERGY INTAKE OF 105 INDIVIDUAL SUBJECTS CALCULATED FROM THE TOTAL INTAKE DURING ONE WEEK. MJ PER MAN PER DAY.

	Total	Protein	Fat	Carbohydrate	Alcohol
Mean	13.73	1.64	4.59	5.34	2.16
Range	5.27-28.10	0.83-3.09	1.76-7.78	2.27-10.71	0-12.70

TABLE 11. DAILY ENERGY INTAKE FOR 105 INDIVIDUAL SUBJECTS CALCULATED FROM THE TOTAL INTAKE DURING ONE WEEK. MJ PER MAN PER DAY.

	Cookhouse Breakfast	Cookhouse Midday	Cookhouse Evening	Outside Purchase	Alcohol
Mean	1.10	1.95	2.20	6.32	2.16
Range	0-4.28	0-5.52	0-4.93	1.91-13.46	0-12.70

TABLE 12 COMPARISON OF ENERGY INTAKE OF THE 20 SUBJECTS EATING MOST BREAKFASTS WITH THE 20 EATING LEAST BREAKFASTS. MJ PER MAN PER DAY. CALCULATED FROM TOTAL EATEN DURING ONE WEEK.

	No. of Breakfasts Eaten	Daily Energy Intake	Breakfast Energy Intake
Attenders	119	14.5	2.4
Non Attenders	6	11.7	0.1
Difference	113	2.8	2.3

TABLE 13 ATTENDANCE RATES AS % OF ENTITLEMENT AT MEALS. (14 units excluding MCTC and Northern Ireland.)

Breakfast	Lunch (Midday)	Dinner (Evening)
45	64	62

Breakfast	Main	Other
45	67	62

TABLE 14 VARIATION OF PREPARATION LOSS % OF RAW MATERIAL WITH DIFFERENT CATERING SYSTEMS.

System	Preparation Loss
Military Corrective Training Centre	10.9
Group Catering Aldershot (5 Units)	15.2
Independent Units England, Scotland and BAOR (9 Units)	23.2

THE NUTRITIVE VALUE & THE EFFECTS OF STORAGE ON OPERATIONAL RATIONS

By

COL. H. H. SAAS

DENMARK

P A P E R   N O T   S U B M I T T E D

WATER, THE ESSENTIAL ELEMENT IN THE DIET

Presentation by Ralph F. Goldman, Ph.D.
To the 3rd International Meeting on
Food for the Armed Forces

15 October 1975
Natick, MA

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The wide range of values for water requirements in the military guides of different countries is reviewed. One of the key reasons for this variability is that water requirements are highly correlated with sweat losses. Sweat evaporation is the major means of body temperature regulation during exercise, particularly in hot environments, but even in the cold. The data base for sweat production is extremely well developed for working men as a function of air temperature. Adequate data also exist for men confined in aircrew or armored fighting vehicle compartments.

The relationship between environmental plus work stress and sweat production is so attuned, that one of the environmental stress indices, the Predicted 4 hour Sweat Rate (P4SR) is based on this relationship. However, water requirements are usually established on the basis of ambient air temperature. Recently, the WBGT index of environmental stress is being used as a base for expressing water requirements.

Another factor in the variability of requirements is that heavier men produce more sweat and, correspondingly, require more water than lighter men. One recommendation is for one additional liter/man/24 hrs for every additional 5 kg of body weight above a 69 kg average body weight.

A fourth factor for the variability in water requirements, in addition to ambient temperature, work level, and body weight is whether work is done in the sun or shade. Up to 4 liters/man/24 hrs can be saved by having the man rest by day and work at night.

The concern with adequate water intake is based upon a large number of studies, regularly repeated every 12-15 years since the second World War, which show that rectal temperatures are increased by about 0.5°C during work at a constant temperature for every additional percent of body weight loss (which is taken as the measure of dehydration) beyond the 2% level of dehydration; i.e., a 70 kg man appears to be able to tolerate 2% dehydration (= a weight loss of 1.4 kg) without difficulty, but will suffer an increase of 0.5°C in his working rectal temperature for every additional 1% dehydration. For planning, we consider a 5 or 6% level of dehydration incompatable with normal military function of the soldier. Levels of 10% dehydration are associated with difficulty in walking.

Thirst is an inadequate stimulus for water ingestion. Studies in the 1940's from the U.S., in the 1950's from Israel, in the 1960's from South Africa, all document that men given no water have severe problems working in the heat, men given water ad lib suffer "voluntary dehydration" levels up to 5%, and an associated performance decrease, and it is only when the men are weighed and required to drink amounts to maintain initial body weight, that performance is relatively unimpaired. Distinct problems with delivery of adequate water to the combat soldier are marked in two areas; extreme cold, where water freezes and the degree of dehydration of the troops can be identified by the color of the "snow flowers" left by urination, and during wear of chemical protective clothing when, even if the gas mask is equipped with a drinking tube device, the inconvenience is such that water intake must be strongly encouraged by command control.

While sweat productions of up to 2.5 liters/hr have been observed, the usual figure for sustained sweat rate during work in the heat is 1 liter/hr. This value is compatible with the upper recommended water levels of from 10-20 liters/24 hrs/man. Minimum water levels for sustained military performance over several weeks, even in a comfortably cool 24°C environment, appear to be about 1.8 liters/day. Although half that amount (900cc/24 hrs/day) is tolerated reasonably well for 5 days, at this level, capacity for heavy work is impaired by the 3rd - 4th day at 24°C, with rectal temperatures rising because of the 3-4% dehydration level incurred by then. However, moderate work levels and more routine work performance do not appear to be demonstrably degraded.

Finally, for best soldier acceptance it appears that water should be comfortably cool (about 23°C), and either unflavored or slightly tart rather than sweet. Maximum retention of ingested water occurs if water losses are replaced by periodic sips, rather than a large quantity ingested once each hour. In conclusion, although there is extensive documentation of the problems resulting from limited water supply, particularly for men working in heat, there is little to show that excess water supply has ever impaired the soldier's performance. Therefore, those charged with supplying water are urged to err on the side of over rather than undersupply.

Nutritional Requirements of German Servicemen

Dr. E. Sommer

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Federal Ministry of Defense, Bonn

Mr. Chairman, Ladies and Gentlemen,

I greatly appreciate the opportunity to give you an outline survey of the requirements to be met by the subsistence and nutrition of our servicemen.

The provision of food to our servicemen is the responsibility of the Federal Armed Forces Administration. Later on, this subject will be dealt with in detail by Herr Pohl who is head of section in MOD Bonn and responsible for these matters.

The supervision of the handling of foods and necessities, especially the handling of food by the Bundeswehr food service in compliance with the laws relating to food production and distribution is the responsibility of medical officers who give professional nutritional advice (physicians, veterinarians, and pharmacists). The subsistence procured by the administration is continuously spot-checked in Bundeswehr laboratories, both microbiologically and for composition and quality. For every 30 persons participating in messing one sample is taken per year. Additional samples will be taken in cases of suspected food deterioration or to follow up earlier findings. The object of this is to ensure that the servicemen receive highly nutritious food, since the demands made upon them are often greater than in the civilian sector.

Great importance is attached to the preservation of the nutritive values during the storage and preparation of food, and prepared meals are also subject to both microbiological and chemical spot-checks.

Whenever new kitchen equipment is bought, we change from the traditional cooking and frying methods to modern techniques of food preparation which are designed to preserve the nutritive value of the foodstuffs used.

The unit medical officer in his capacity as advisor to the commander and the administration has an important preventive medicine function in subsistence planning, especially in requirement-oriented menu planning, including the provision of estimates of nutritive values. Our previous guidelines for an adequate nutrition have been adjusted to present-day requirements, as the physical demands on the servicemen have decreased over the last two decades, due to the increasing motorization and mechanization.

A comparison between the recommendations of the U.S. Food and Nutrition Board from 1953 through 1974 shows that the average amount of calories required by man has decreased. Our new guidelines are based on the assumption that the servicemen required to take part in messing are about 20 years old. Since after completing their basic training these servicemen at least engage in regular sport activities and, as a rule, are physically more active than older servicemen we must base our calculations on a minimum calorie requirement of 2800 kcal. During the basic training, it is sufficient to provide subsistence for medium physical activity. For most activities a calorie supply of 3400 kcal will be adequate. In order to adjust the calorie intake to varying requirements it is also possible to apply intermediate figures. Higher figures are only permissible when substantially greater requirements must be met. According to the menus analyzed, heavy physical work requiring a calorie intake of 4000 kcal and more is performed only in 10 per cent of all cases.

Performance-oriented Diet

Adjustment of Diet to Occupation

Occupation	Calories (kcal)	Fat (g)	Protein (animal) (g)	Vitamin A (mg)	Thiamin (mg)	Vitamin C (mg)
light physical	2800	105	60	0.9	1.8	75
medium physical	3400	128	60	0.9	2.1	75
heavy physical	4000	150	60	0.9	2.5	75

Our aim is to provide 3200 kcal on the average. Our medical officers receive detailed advice about an adequate classification of personnel according to their calorie requirements.

For this purpose we rely mainly on the publications of Consolazio, Durnin, and Passmore. We are also planning to carry out our own investigations in this field.

I should mention that, as a rule, servicemen up to the age of 25 are required to take part in messing. Older long-time or career servicemen are required to take part in messing only when they perform special duties, for example during exercises. They are allowed, however, to take part on a voluntary basis against payment. Messing is the same for all servicemen required to take part and it is not possible to cater for individual nutrient requirements. It is the responsibility of the medical officer to inform the servicemen accordingly and to recommend older servicemen or those who are less active to restrict their intake at lunch for instance by taking no soup or other menu items.

According to our guidelines, the average fat calorie content of food should be 35 per cent. It is our aim to reduce the fat calorie content from the present figure of about 40 per cent to 35 per cent by continuously informing our medical officers and kitchen workers on the methods of a low fat diet and the advantages of a low fat content, especially in meat, sausage and cheese.

The analysis of menus has shown that the requirement for 60 g animal protein has been met in all cases. The average intake of animal protein is 68 g and the overall protein content is 105 g. This figure is considered adequate, even assuming that the servicemen do not eat any other food than messing rations. Recent investigations by Consolazio have confirmed this. He showed that 1.4 g protein per kilogram body weight is sufficient for physically active personnel. For major physical activities additional messing allowances are available which serve to increase the calorie content or specifically the protein content.

The vitamin figures in the table refer to the foodstuff used and do take into account the losses caused by food preparation. In the diet provided by the food service of the Bundeswehr, the guiding figures for vitamins A and C are exceeded and those for vitamin B_1 are equalled. We are trying to reduce vitamin losses by shortening the period between the preparation and the consumption of food.

As I mentioned before, we also use estimates of nutritive values. We do not compute specific nutritive values for any particular food, but we rather group together foods of similar nutrient and biocatalyst content. The nutritive value of sausage, in particular, was taken from the findings obtained by regular sampling. Meat was classified, according to its fat content, in categories from very lean to very fat. The Annex to our guidelines shows which categories are applicable to the various types and kinds of meat. The first step in the analysis of a week's menu is to group the various foods together by type and to add up quantities of the same type. The result is translated into estimated nutritive values. After the nutritive values have been computed and added together the values obtained for a week's menu are converted into average daily figures. The same system can be applied to an analysis of daily menus and individual meals. For all practical purposes, however, it will be sufficient that the weekly average meets the requirements. Differences between individual days are permissible as long as the varying levels of physical activity are taken into account.

An analysis of body heights and weights of approx. 4.7 million men liable to military service carried out by the Federal Armed Forces Institute for Medical Statistics and Data Processing showed that the average height of men born in 1950 as compared with the men born in 1937 has increased by 2.6 cm. The average increase in weight for the same period is 2.5 kg. This increase is not due to the general increase in body weight but to the increase in height. The share of men who have below-average height (165 cm or less) has decreased from 9.7 per cent to 4.8 per cent, while the percentage of men of medium height (166 to 184 cm) remained constant and the share of the above-average height group (185 cm and more) has increased from 4.6 to 9.7 per cent.

An analysis of weight trends observed in 225,000 servicemen during their basic military service showed that after 18 months of basic military service (service entrants of 1968 and 1969) 74 per cent of the servicemen had put on weight, 9 per cent had kept their weight, and 17 per cent had lost weight. The majority of lightweight individuals had gained in weight while the majority of heavyweight individuals had lost weight. These findings are essentially identical with those obtained in 1938 and from 1961 to 1963. The average increase in weight was 4 kg and the average loss was 3 kg.

Presently, we are developing anthropometrical procedures which are designed to obtain more accurate results on the physical development of men during their term of service, especially with regard to the share of adipose tissue.

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U.S.A.

AMOUNTS AND NUTRITIONAL ADEQUACY OF FOODS CONSUMED OUTSIDE OF MILITARY DINING FACILITIES

Introduction

Adequate nutrition is necessary for optimum performance of military personnel. Troops in the field are supplied with field rations which contain adequate nutrients and are augmented with only a limited selection of canteen items. However, personnel in garrison status have more freedom to select their food from several sources. Until recent years, most enlisted personnel ate in a company dining hall which offered one or two entrees and a limited choice of other items. Attendance was quite high. Surveys conducted during the 1950's by the United States Army Medical Nutrition Laboratory (1, 2, 3, 4) showed that troops consuming an average of 3500 kilocalories within their company dining hall consumed an additional 500 or more kilocalories per day from other sources.

More recently liberal policies allowing single personnel to live outside of billets and increased non-duty-hours freedom of movement have made military service much like civilian life. Also, many sources of food have become available through the proliferation of vendors, fast food shops and restaurants on or near military installations, all of which compete with the military dining hall for the attendance of the serviceman. As a larger proportion of enlisted personnel are converted from a rations-in-kind (RIK) to a basic allowance for subsistence (BAS) meal status, the attendance at the military dining halls has decreased and a concern has been expressed as to whether the young single enlisted person is able to effectively manage his finances and obtain adequate nourishment even with a low attendance at the dining hall. Food service has attempted to produce more variety in the dining halls and offer popular items through short order lines.

Recent nutrition surveys have been conducted at military dining facilities. However, while offering a good description of food and nutrients consumed within these facilities, many did not deal with total daily food consumption from all sources on a per-man basis.

Two studies were conducted by Letterman Army Institute of Research to estimate the total daily nutrient intake of military personnel from all sources by using a dietary recall and diary method. The first study was designed to assess whether RIK personnel were meeting their nutrient allowances as dictated by Army Regulation 40-25. The second study was conducted to determine if there was a difference among the nutrient intakes of three groups of personnel; RIK, BAS-Single and BAS-Married persons and to determine whether intakes were adequate.

Methods and Materials

A study was conducted in October 1973 at Ent Air Force Base, Colorado, in which food intake data were collected for 14 days upon

149 enlisted men with a RIK status. Each man was given an initial 24-hour recall interview to acquaint him with our needs and procedures. At this interview seven pocket-sized food consumption diary cards (one for each day) were issued, their use explained and a diary review session scheduled at the end of seven days. At the review session the diary was discussed with the subject to insure completeness and accuracy and a second week's diary was issued. At the end of the second week the diary was reviewed again.

Upon completion of the study all records were coded and verified. Daily nutrient intake for each subject was computed with a computer using our nutrient factor file, which is a compilation of many food composition tables, such as USDA Handbook No. 8 (5) and Bowes and Church Food Values (6).

The second study which will be reported in this paper was conducted jointly by Letterman Army Institute of Research and ORSA, Army Development Center at Naval Air Station Alameda, California in March 1975. In this study three groups of subjects were chosen according to meal and marital status. The three groups were: RIK, BAS-Single and BAS-Married.

The data collection method was similar to that used at Ent AFB except that diary reviews were held every three days instead of weekly in order to insure that the subjects were not waiting to use their diaries until immediately prior to the review sessions. Data processing was also similar to that for the Ent AFB study.

Results and Discussion

At NAS Alameda the average daily food consumption and intake of most nutrients were near the daily dietary allowances (DDA). Average daily food consumption and average intakes of the macro-nutrients for the three groups at NAS Alameda are shown in table 1. The RIK group was highest in each of the nutrients with the BAS-Single group intermediate and the BAS-Married group lowest.

The BAS-Single and BAS-Married groups differed ($p<.05$) only in carbohydrate and energy intake. All three groups were well below the DDA for energy of 3400 kilocalories.

Protein intakes were different ($p<.05$) among the three groups with only the RIK group meeting the DDA of 100 grams. The average daily intake of food, energy, protein and fat from meals from the several sources is shown in figure 1. It is evident from this figure that attendance at the military dining hall was very different ($p<.01$) among the three groups. The RIK group, as expected, were the most frequent attenders (one meal per day) and consumed about one-half of their meal-time nutrients at the dining hall. Attendance of the BAS-Single group was much lower and the married group rarely ate at the dining hall. Nutrient intake per dining hall meal consumed did not differ among the three groups and the average per meal energy intakes were about 1200 kilocalories. Meal-source patterns of the RIK and BAS-Single groups are interesting. Intake from vendors and restaurants are almost equal for each nutrient. However, the dining hall and at-home consumption are just the opposite for the two groups. The BAS-Single group consumed about one-half of their meal-time nutrients at home while the RIK personnel obtained one-half of most nutrients at the dining hall. It appears that the change in meal status from RIK to BAS greatly affects dining hall attendance although food consumption at home nearly compensates for this lack.

The BAS-Married group showed a significantly ($p<.01$) lower consumption at vendors and restaurants than did the single groups. The time patterns between the single and the married groups were also different. Single personnel showed increases in restaurant consumption during weekends while the married group had no daily differences.

Between-meal or snack macro-nutrient intakes were quite similar among the three groups with home and vendors contributing most. These data are shown in figure 2. The proportion of the daily energy intakes from snacks were highest in the RIK group and lowest in the married group.

Vitamin intakes are shown in figure 3. The vitamin A value of the RIK group is lower than the 5000 IU per day DDA, although the values of the other two groups are adequate. Thiamin is low for all three groups. Riboflavin, niacin and ascorbic acid are adequate for all three groups.

Calcium, phosphorus and iron intakes are shown in table 2. Both calcium and iron intakes are above the DDA. Calcium intakes for the RIK group were significantly higher ($p<.05$) than the other groups. This can be attributed to a higher consumption of milk at meals in the dining hall. This is shown in figure 4. Desserts, which include non-milk product desserts and sugars, did not account for much of the daily nutrient intake. Consumption was quite low in both meals and snacks in all three groups. Most meal-time nutrient intake came from entree items, which are basically meat or grain based products. Vegetables and soups are included in the miscellaneous food group.

Alcoholic beverage consumption from between meals differed among (figure 5) the three groups. The RIK group averaged 680 grams per day, which was more than double that of the other groups. Consumption was higher on weekends than on the weekdays as would be expected.

Non-alcoholic beverage intakes were higher in the married group and in the BAS-Single group. The large quantity and low nutrient intakes are due to a large proportion of this category as coffee. It appears that the younger RIK personnel drink less coffee but drink more alcohol than the married persons. Soft drink consumption was about the same for the three groups.

The frequency of consumption of the non-dining hall food items was tallied with all groups combined in order to determine the most popular snack items. These frequencies are shown in table 3 for the NAS Alameda study and in table 4 for the Ent AFB study. Only the most frequent items are included. Coffee, milk, alcoholic beverages and soft drinks are the common, most frequently consumed items in the two studies. These are followed by French-fried potatoes and the various sandwich ingredients such as lettuce, tomato, bread, butter and related condiments. Ice cream and cheese consumption was high in both studies. It should be noted that the food item descriptions of cheeseburgers, etc. include McDonalds. This is only because the nutrient composition of these products were available and were used as standards for our convenience. Similar products from other vendors were frequently consumed.

Average daily nutrient intakes of the RIK personnel at Ent AFB are compared to those of the RIK group at NAS Alameda in table 5. The values for every nutrient are almost the same. The nutrients which are below the DDA are energy and thiamin. The Ent group averaged just over one meal per day in the dining hall and the NAS Alameda group averaged just under one meal per day. The performance of the two groups, even though in different services and locations was very similar. Data from the Ent study show that the RIK personnel on the average must eat at least one and one-half meal per day in the dining facility to meet the DDA for all nutrients.

Summary and Conclusions

Data were shown for two studies to determine whether enlisted personnel with a meal status of RIK are acquiring adequate nutrition. In the second study the nutrient intakes of a RIK group were compared to a single and a married group with the meal status of BAS. Average daily nutrient intakes of the RIK group were highest with the BAS-Single group intermediate and the married group lowest. The sources of the nutrients were much different. The RIK group frequented the dining facilities on base much more than the BAS-Single group. The BAS-Single group attended more frequently than the married group. It appears that the young military man is able to adjust to the opportunities and environment confronting him. The BAS-Single and RIK personnel were able to obtain adequate nutrition through a combination of attendance at the dining hall and food consumed at home.

REFERENCES

1. Consolazio, C.F., Hawkins, J.M., Berger, F.M., Johnson, O.C., Katzanek, B. and Skala, J.H.: Nutrition survey of two consecutive training cycles of the Airborne Training Bn., Co. "G", Fort Benning, Georgia, Oct-Nov 1953. MNL Report 166, May 1955.

2. Kuhl, W.J., Best, W.R., Berger, F.M., Consolazio, C.F. and Friedmann, T.E.: Nutrition survey of two company messes, Camp Pickett Virginia, 8 September to 3 October 1952. MNL Report 104, December 1952.

3. Parrott, E.M., Friedmann, T.E., Consolazio, C.F., Kuhl, W.J., Jr., Best, W.R., Krzywicki, H.J., Powell, R.W., Farley, J.E., Gates, C.M., Caranna, L.J. and DeCrease, W.M.: Nutrition survey of a company mess, Fort Sheridan, Illinois 9-13 and 23-27 June 1952, MNL Report 100.

4. Myer, R., III, Consolazio, C.F. and Berger, F.M.: Nutrition survey of two company messes, 10th Infantry Division, Fort Riley, Kansas. MNL Report 128, April 1954.

5. Watt, B.K. and Merill, A.L.: Composition of foods. Agriculture Handbook No. 8, USDA, Washington, D.C., 1963.

6. Bowes and Church. Food Values of Portions Commonly Used. 11th Ed. J.P. Lippincott Co., Philadelphia, PA, 1970.

Table 1. Average Daily Total Intake of Food, Water, Energy, Protein, Fat, Carbohydrate, Fiber and Ash of Rations-in-Kind, BAS-Single and BAS-Married Personnel at NAS Alameda, CA, March 1975

NUTRIENT	RIK	BAS-S	BAS-M
Quantity (g/day) *	2804a	2616ab	2508b
Water (g/day)	2222	2095	2034
Energy (KCal/day)	2945a	2617b	2374c
Protein (g/day)	106a	98b	95b
Fat (g/day)	119a	112ab	106b
Carbohydrate (g/day)	299a	260b	229c
Fiber (g/day)	3.5	3.3	3.3
Ash (g/day)	17.6a	16.7ab	15.8b

*Means in the same row with different subscripts are significantly different ($P < .05$)

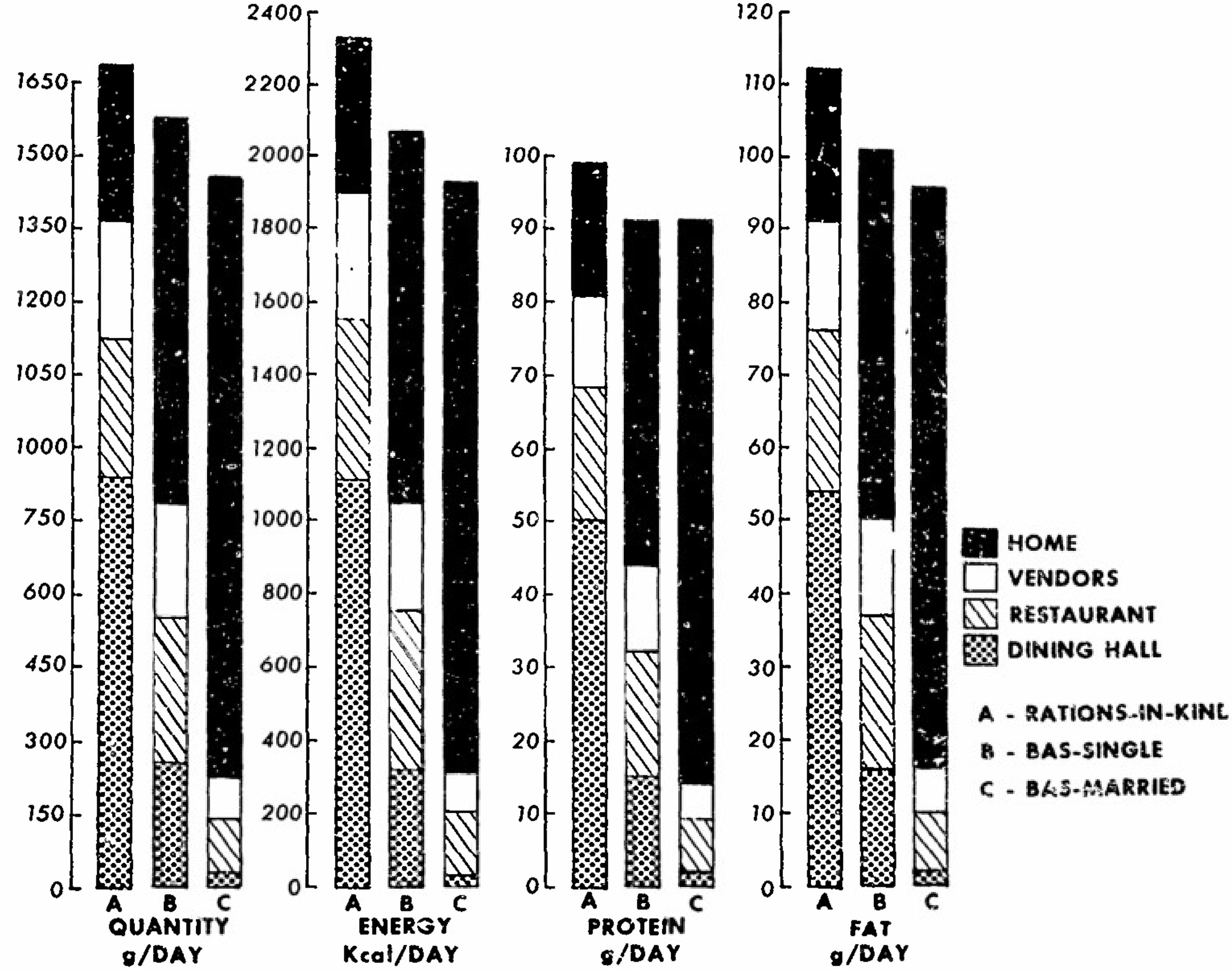

FIGURE 1. AVERAGE DAILY INTAKE OF FOOD, ENERGY, PROTEIN AND FAT FROM MEALS EATEN AT MILITARY DINING HALL, RESTAURANTS, VENDORS AND HOME FOR RATIONS-IN-KIND, BAS-SINGLE AND BAS-MARRIED NAVY PERSONNEL AT NAS ALAMEDA, CA, MARCH, 1975

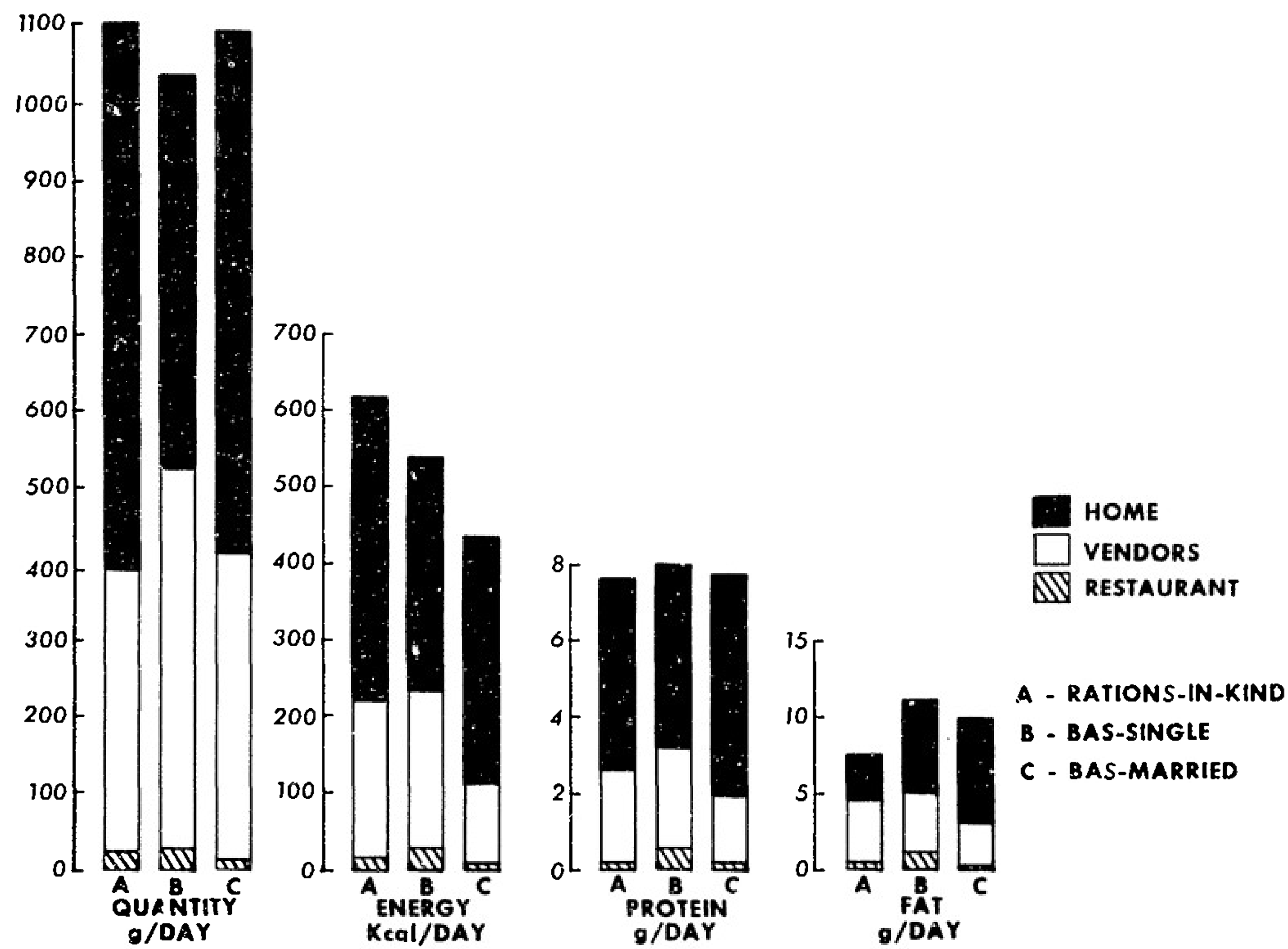

FIGURE 2 AVERAGE DAILY INTAKE OF FOOD, ENERGY, PROTEIN AND FAT FROM SNACKS EATEN AT MILITARY DINING HALL, RESTAURANTS, VENDORS AND HOME FOR RATIONS-IN-KIND, BAS-SINGLE AND BAS-MARRIED NAVY PERSONNEL AT NAS ALAMEDA, CA, MARCH, 1975

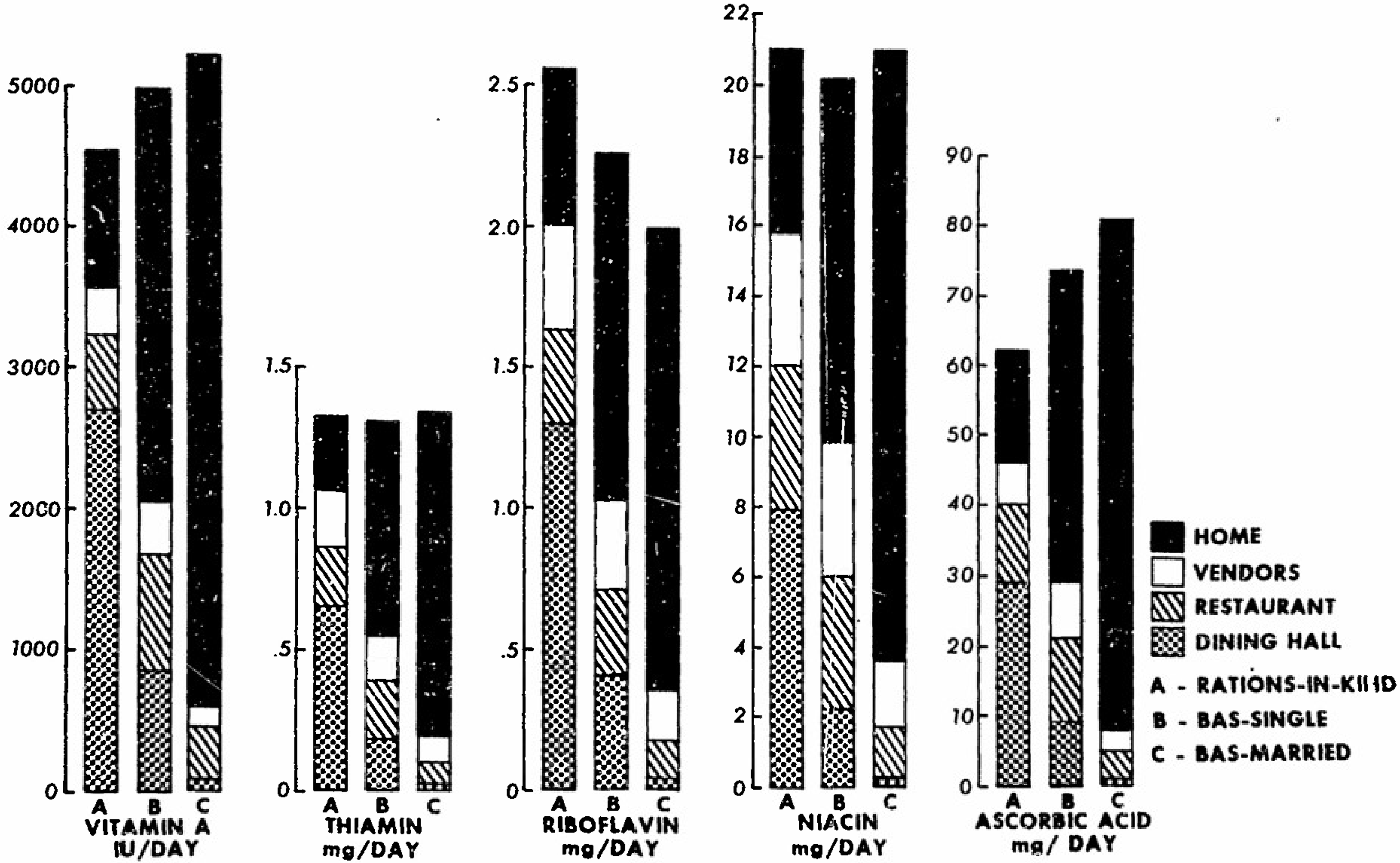

FIGURE 3 AVERAGE DAILY VITAMIN INTAKE FROM MILITARY DINING HALL, RESTAURANTS, VENDORS AND HOME FOR RATIONS-IN-KIND, BAS-SINGLE AND BAS-MARRIED NAVY PERSONNEL AT NAS ALAMEDA, CA, MARCH, 1975.

Table 2. Average Daily Intake of Calcium, Phosphorus and Iron of RIK, BAS-Single and BAS-Married Navy Personnel at NAS Alameda, CA, March 1975

	CALCIUM	PHOSPHORUS	IRON
TOTAL FROM MEALS			
RIK	1046	1510	14.1
BAS-Single	835	1274	13.9
BAS-Married	674	1186	14.8
TOTAL FROM SNACKS			
RIK	92	84	1.1
BAS-Single	129	146	2.1
BAS-Married	131	151	1.4
DAILY TOTAL			
RIK	1138	1594	15.2
BAS-Single	963	1420	16.1
BAS-Married	805	1337	16.3
Daily Dietary Allowance AR 40-25, 1972.	800	----	14.0

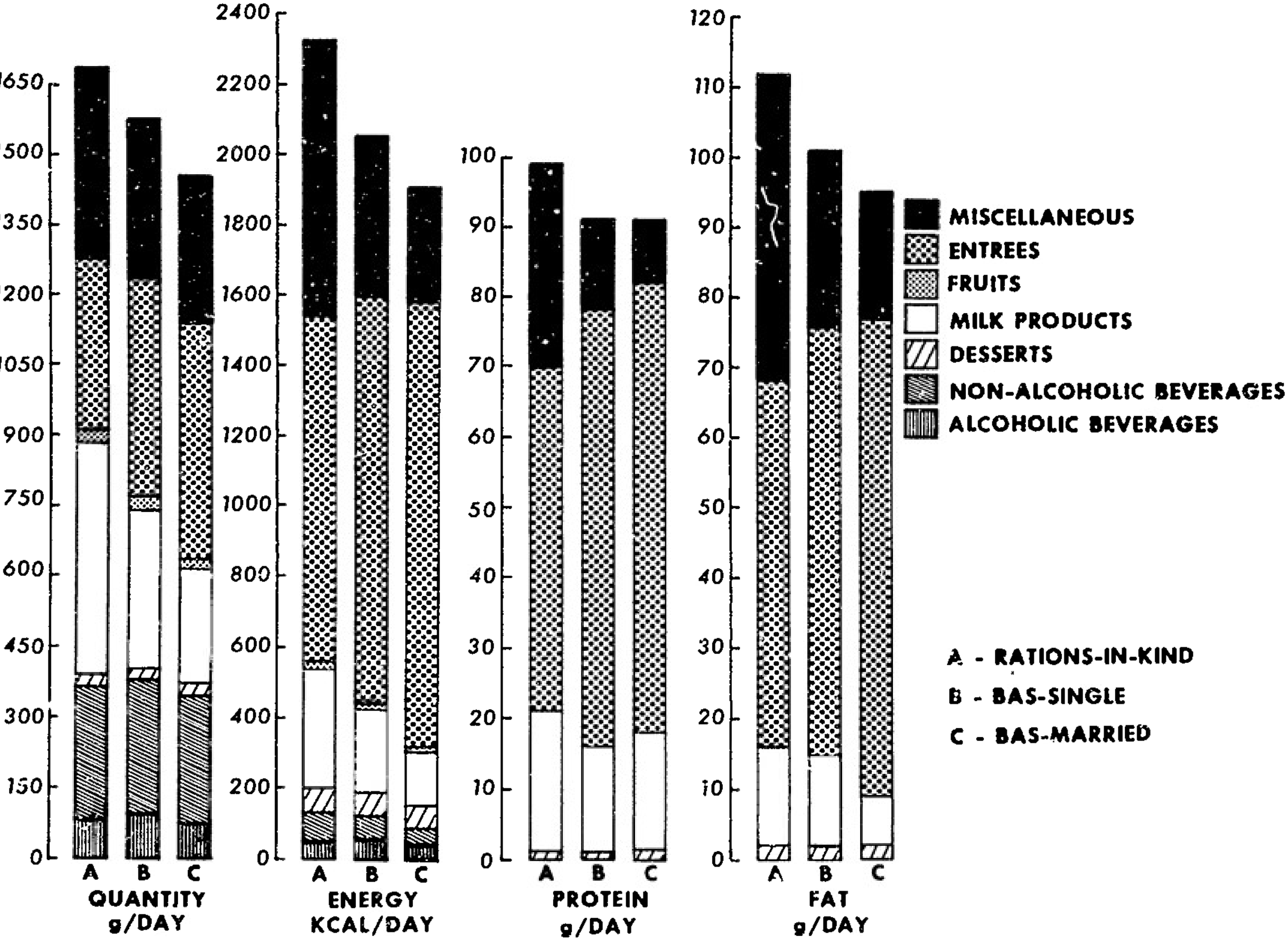

FIGURE 4. AVERAGE DAILY INTAKE OF FOOD, ENERGY, PROTEIN AND FAT BY FOOD TYPES FROM MEALS EATEN BY RATION-IN-KIND, BAS-SINGLE AND BAS MARRIED NAVY PERSONNEL AT NAS ALAMEDA, CA, MARCH, 1975.

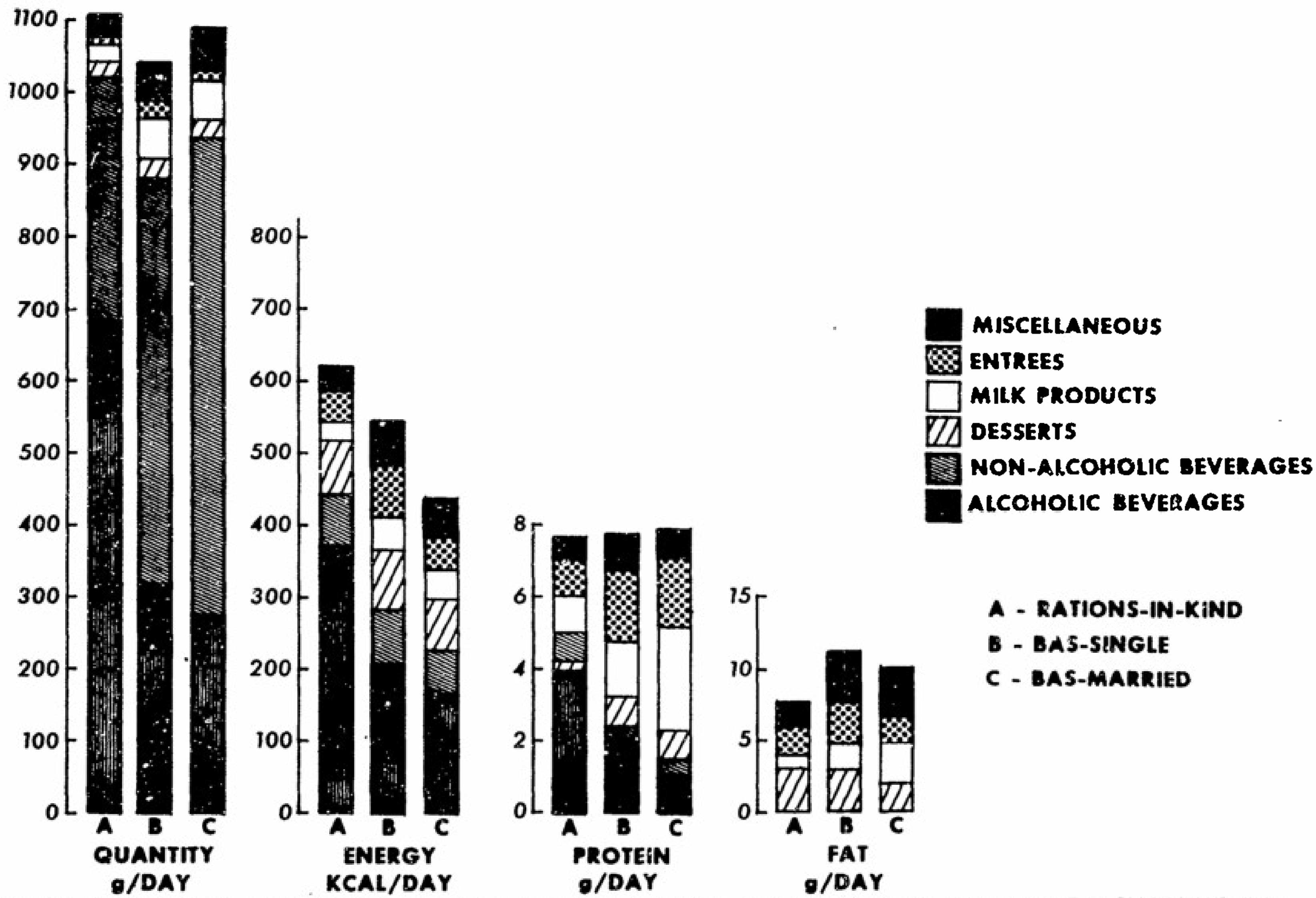

FIGURE 5. AVERAGE DAILY INTAKE OF FOOD, ENERGY, PROTEIN AND FAT BY FOOD TYPES FROM SNACKS EATEN BY RATIONS -IN-KIND, BAS-SINGLE AND BAS-MARRIED NAVY PERSONNEL AT NAS ALAMEDA, CA, MARCH, 1975.

TABLE 3. FREQUENCY OF INTAKE, NON-MESSHALL FOOD ITEMS AT NAS ALAMEDA, CA, MARCH 1975

DESCRIPTION	TOTAL
Coffee, Beverage	2836
Sugars, Beet/Cane, Granulated	1388
Milk, Cow, Whole, 3% Fat Estimated	1317
Beverages, Carbonated, Cola	1301
Breads, White, Enriched, Non-Fat Milk	941
Butter	899
Beverage, Alcohol, Beer, 3.2 Vol %	818
Milk, Cow, 2%	711
Eggs, Chicken, Cooked, Fried	476
Potatoes, French-Fried	461
Tea, Instant, Beverage	368
Tomatoes, Ripe, Raw	358
Cream, Substitutes, Skim Milk, Dry	331
Salad, Tossed	316
Lettuce, Raw, Butterhead Var	309
Beverages, Alcohol, Whiskey, 80 Proof	295
Rice, White, Enriched, Cooked	291
Bacon, Cured, Broiled/Fried, Drained	248
Ice Cream, Frozen, Custard, 12% Fat	234
Potato Chips	228
Salad Dressings, Commerical Mayonnaise	223
Breads, Whole Wheat, Non-Fat Milk	215
Beverages, Carbonated, 7Up/Sprite	214
Mustard, Prepared, Yellow	211
Orange Juice, Frozen, Diluted 1 to 4	198
Cheese, Processed, American	192
Oranges, Peeled, All Var	182
Beverages, Carbonated, Fruit-Flavored	171
Tomato Catsup, Bottled	166
Margarine	151
Beverage, Alcohol, Wine, Table, 12.2 Vol %	148
Eggs, Cooked, Scrambled	146
Milk, Cow, Chocolate, Whole	145
Bananas, Raw, Common	144
Potatoes, Mashed/Milk	142
Cream, Light, Coffee, Table	135
Beef, Ground, Hamburger, Cooked	126
Gravy, Fat and Flour	122
Breads, French/Vienna, Enriched	120
Potatoes, Baked in Skin	114
Eggs, Hard-Cooked	113
Sausage, Cold Cuts, Bologna	112
Chicken, Cooked, Fried, Flesh and Skin	108
Pizza, Home Recipe, Cheese, Sausage	107
Sandwich, Hamburger, ¼ Lb., McDonald	105

TABLE 4. FREQUENCY OF INTAKE OF NON-MESSHALL FOOD ITEMS AT ENT AFB, CO, OCTOBER 1973

FOOD ITEM	TOTAL
Bavarages, carbonated, cola	1206
Coffee, beverage	1015
Milk, whole, fresh, pasteurized, homogenized	680
Beverage, alcohol, beer, 4.5 vol %	625
Breads, white, enriched, non-fat milk	603
Sugers, beet/cane, granuleted	519
Beverages, cerboneted, fruit-flavored	377
Potatoes, French-fried	270
Beverages, alcohol, whiskey, 80 proof	267
Cream substitutes, skim milk, dry	198
Potato chips	192
Butter	189
Cream, light, coffee, table	176
Sandwich, hamburger, McDonalds	170
Bevaragea, carbonated, Sprita/7Up	161
Tea, instant, bevarage	151
Eggs, chickan, cookad, fried	137
Pizza, home recipe, cheese-sausage	133
Baverage, beer, 3.2 vol %	132
Doughnuts, cake type	120
Sandwich, cheeseburger, McDonalds	119
Beverage, alcohol, wine, teble, 12.2 vol %	116
Lettuce, raw, butterhaad, var	108
Orange juice, frozen, diluted 1 to 4	107
Cheese, processed, American	103
Rolls and buns, commercial sweet rolls	101
Apples, raw, not pared	100
Selad, tossed	86
Sandwich, submarine	85
Milk shake with ice cream	84
Tomatoes, ripe, raw	83
Potatoes, mashed/milk	83
Sandwich, ham and cheese	77
Pork, cured, canned ham	76
Sausage, cold cuts, bologna	75
Sandwich, cheeseburger (Big Mac)	74
Ice cream, frozen, custerd, 12% fat	73
Potatoes, frozen, French-fried, heated	72
Corn chips	68
Salad dressings, commarcial mayonnaise	68
Peanut buttera, added fat, salt	57
Beverages, carbonated, root beer	56
Tacos	56
Popcorn, popped, soil-salt edded	53
Chewing gum	53
Potatoes, bakad in skin	53
Bacon, cured, broiled/fried, drained	53
Crackers, saltinea	52
Sandwich, frankfurter	50

TABLE 5. AVERAGE DAILY NUTRIENT INTAKE OF RATIONS-IN-KIND PERSONNEL AT ENT AFB, CO (OCT 1973) AND NAS ALAMEDA, CA (MAR 1975)

	ENT AFB (14 Days)	NAS ALAMEDA (17 Days)
Quantity (g/day)	2679	2804
Water (g/day)	2057	2222
Energy (KCal/day)	2794	2496
Protein (g/day)	98	106
Fat (g/day)	116	119
Carbohydrate (g/day)	299	299
Fiber (g/day)	3	3
Ash (g/day)	19	18
Calcium (mg/day)	1191	1138
Phosphorus (mg/day)	1541	1594
Iron (mg/day)	14	15
Vitamin A (IU/day)	5882	4543
Thiamin (mg/day)	1.69	1.33
Riboflavin (mg/day)	2.55	2.57
Niacin (mg/day)	21	21
Ascorbic Acid (mg/day)	74	62

APPLICATION OF NUTRITIONAL PRINCIPLES

TO

BRITISH ARMY RATION PACK

By

COL. D. E. WORLSEY

U.K.

P A P E R   N O T   S U B M I T T E D

Energy intake and energy expenditure of a group of 20-30 year old Dutch Navy personnel in training for non commissioned officer

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SUMMARY

Food intake, energy expenditure and nutritional status of 57 trainees for non commissioned officer in the Dutch Navy have been measured. Compared to Navy-recruits and to comparable young adults the % body fat of this group is higher. The daily calorie intake of the group was 4105 Kcal. Snacks and alcohol accounted for 26 % of the calories. The daily energy expenditure was only 2805 Kcal. Resting metabolism accounted for 62 % of this energy expenditure.

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INTRODUCTION

Since 1957 the Central Institute for Nutrition and Food Research in the Netherlands has undertaken studies on the nutritional statue of different groups of the Dutch Army. As there is a growing concern of the medical corps of the Dutch Royal Navy about the development of overweight by an increase in body fat, these studiee have been directed from merely descriptive, anthropometric studiee towards studies on the factore influencing the nutritional statue. In this paper the results of a recent study on trainees for non-commissioned officer are compared with thoseof a previous study on recruits.

SUBJECTS

The subjects of this investigation were three consecutive groups of trainees for non commissioned officer in the Royal Dutch Navy (NCO-group) amounting to a total of 57 men. They were 20-28 years old with a mean age of 22.6 years. They have been observed during their 8-week training. In these 8 weeks they are physically more active than during their preceding or following military service. The daily activity pattern, the nutritional intake and the nutritional status of this NCO-group have been compared with those of a previously etudied group of recruits. The recruit-group consisted of 31 Navy-recruits; they were 17-20 years old with a mean age of 17.6 years. They have been followed previously during their 9 weeks first military training (FMT-group)(1). The anthropometric data of both groups are presented in table 1.

METHODS

The food-intake has been determined by weighing the total food served to the three consecutive NCO-groups and to the recruits at each meal during five days. Unserved portions and plate waste were also weighed.The raw ingredients have been weighed before cooking. Unfortunately individual assessment was impossible for practical reasons. The amount of snacks and alcohol was assessed by means of daily records the subjects filled in by themselves during 1 week and crose-checked by interview.

The daily activity-pattern and energy-expenditure has been assessed by the following methods:

1. Interview on the daily activity-pattern by an experienced interviewer. This lasted 30 to 45 minutes per subject. The detailed schedule of the compulsory military training (8 a.m. till 5 p.m.) was known and this was incorporated as a check on the interview.
2. Individual activity-diaries were kept by the subjects thomselves. They coded their activities at 5-minutes intervals over 24 hours, again including the military training.
3. Timed activity studies for various periods of time by observing several types of activities. In the previous study of the FMT-group the energy expenditure has been calculated from diary recorde and timed activity studies without measuring the metabolic cost of the different activities. The metabolic rates of those activitiee were taken from eaveral reference tables (2, 3, 4). Ae these tables show variations for supposedly

identical activities we thought it necessary to do measurements under Dutch circumstances.

4. Metabolic cost-measurements of different activities using the portable Max Planck-respirometer. Oxygen concentration in expired air samples was carried out by means of a portable oxygen analyser (Servomex, type OA 101).
5. Resting metabolism-measurements by means of a closed circuit spirometer (Volutest, Mijnhardt Comp.). on two consecutive days, ± half an hour after awakening in the fasting state. We do not pretend having measured the basal metabolic rate in these field circumstances. As this resting metabolism is the largest item of the daily energy expenditure (in our investigations ± 60 %) actually measuring it rather than computing the resting metabolism from body surface reduces the inevitable error in these energy balance studies with smaller groups. The average for the NCO-group was 1750 Kcal., which means ± 1.2 Kcal./min., whereas Edholm et al used a figure of 1.5 Kcal/min. for British Cadets (5).

RESULTS

Table 1. Anthropometric data of N.C.O.-group and recruits

	Non comm. officers N = 57		NORMAL Dutch young adults		Recruits N = 31	
	mean	s.d.	mean	s.d.	mean	s.d.
AGE (yrs)	22.6		23		17.2	
HEIGHT (cm)	180.1	6.3	178.8	5.6	177.2	6.5
WEIGHT (kg)	76.2	11.7	72.9	7.4	63.1	5.6
% BODY FAT (DURNIN)	16.6	5.4	15.7		13.2	3.5

The recruits were newly enlisted and their anthropometric data comparable to normal Dutch adolescents.

However, the 5-year older NCO-group is fatter than the normal Dutch population of the same age. Compared with the recruits, there is an increase in relative weight, as evidenced by the increase in % body fat of 3.4 %. This fat-increment can be due to under-activity, a too abundant food intake or a combination of both.

Table 2. Daily energy intake (in Kcal) of NCO-group and FMT-group

	Non comm. officers	Recruits 1st week FMT	Recruits 9th week FMT
BREAKFAST (kcal)	694		
LUNCH (kcal)	905	3240 (breakfast, lunch, supper)	2705 (breakfast, lunch, supper)
SUPPER (kcal)	1427		
SNACKS (kcal)	778	470	775
ALCOHOL (kcal)	300	10	95
INTAKE TOTAL (kcal)	4105 (alcohol 7.5 %)	3720	3575
INTAKE PER KG BODY WEIGHT (kcal)	54	58	57

These figures are averages of five consecutive days. The intake of the total groups were measured as individual assessment was impossible. During first military training the official Navy-rations supply 3150 Kcal per man per day excluding calories taken by canteen consumption. In the first week the actual intake from rations was higher, apart from the extra 480 Kcal from canteen consumption. The intake per kg body weight per day of the FMT-group is comparable to the 61 Kcal that Edholm et al. found on British Army recruits (6). These 58 Kcal seem more than adequate for these recruits, although their actual weight decreased with 0.9 kilogram during the 9 weeks the FMT lasted. On the other hand the total intake of the NCO-group was considerably higher whereas their Navy-ration supplied them with 250 Kcal less. In this group the alcoholic calories accounted for 7.5 % of the total calorie-intake.

Table 3. Energy expenditure of non comm. officers and recruits

	Non comm. officers			Recruits		FAO/WHO moder. active
	mean	s.d.	range	mean	range	
AGE (yrs)	22.6			.2		20-39
WEIGHT (kg)	76			[illegible]		65
RESTING METABOLISM (kcal)	1745	280	1280-2500	1805	1500-2235	
ACTIVITIES (kcal)	1060	280	850-2250	1250	915-1740	1500
TOTAL ENERGY EXPENDITURE PER 24 HRS (kcal)	2805	395	2130-3680	3055	2550-3885	3000
CALORIE-EXPENDITURE PER KG BODY WEIGHT (kcal)	36.8	5.2	30-52	45.5	39.51	46

The largest item of both groups is the resting metabolism which accounts for ± 60 % of the total energy-expenditure. The calories expended in activities are left out in the cold. In the expenditure for resting metabolism as well as for activities however a great range can be noted. The expenditure per kg body weight of the recruits (who are supposed to be physically active) is the same as an FAO/WHO-expert committee indicates for the expenditure of an onlymoderately active reference-man who spends 2 hours in active recreation when not at work, namely 46 kcal (7). The NCO-group expend even less than the light-activity FAO/WHO reference man: 37 vs. 42 kcal per kg body weight.

On the other side of the coin the intakes of both the military groups (table 2: 54 vs. 57 kcal per kg body weight) are those of the "very active" FAO/WHO-reference man. Were this nomination "very active" applicable to the NCO-group as far as their expenditure is concerned then they should have spent 2.300 kcal on activities instead of the actual 1060 kcal (excluding resting metabolism!).

The daily activity pattern of the NCO-group has been divided in 3 parts: 1. activities in the early morning before roll-call at 8 a.m. 2. the compulsory military program from 8 a.m. till 5 p.m.. 3. the spare-time activities after 5 p.m. in the evening. In table 4 the energy expenditure accounted for by these different parts can be seen as absolute figures (in kcal) and as percentages of total daily expenditure.

Table 4. Energy expenditure of Dutch non comm. officers

	A. Absolute figures (in kcal)			B. figures as % of total		
	Mean	s.d.	range	Mean	s.d.	range
Resting metabolism	1750	280	1280-2500	62	4.9	
Morning activities	55	20	15-125	2	0.8	0.5-4.6
Daily military activities	720	110	550-1065	26	3.2	20-34
Evening activities	280	145	120-770	10	3.9	4-23
TOTAL	2805	395	2130-3680	100		

As well the absolute figures as the percentage figures show a great range of values in every item. Despite its great range in absolute calorie-expenditure, the % value of resting metabolism has a standard deviation of 4.9 %. This is a rather small one compared to those of the military program and the evening activities.

It is somewhat disappointing that the spare-time energy expenditure amounts to only 10 %. This 10 % is only half of what FAO/WHO-experts expect one to expend in non-occupational activities. The 10 % incorporates however a wide range of values!

The NCO-group has been divided into 3 subgroups, according to their % body fat. The percentage distribution of the daily energy-expenditure of these three fat-subgroups have been compared in tabel 5.

Table 5. Non comm.officers: % distribution of energy-expenditure among different fat-groups

	Fat % < 10 %		Fat % 10-20 %		Fat % > 20 %	
	mean	s.d.	mean	s.d.	mean	s.d.
RESTING METABOLISM	70	3.5	62	4.1	60	5.4
MORNING ACTIVITIES	2	0.4	2	0.8	2	0.9
DAILY MILITARY ACTIVITIES	22	2.9	26	2.7	27	3.5
EVENING ACTIVITIES	6	1.5	10	3.8	11	4.0
	100		100		100	

The only statistical significant difference in % energy-expenditure between lean and fat groups is for the military activities ($p > 0.5$). Although there is no statistically significant difference between groups in the evening activities, it seems that the fat ones expend a greater

% of their calories in the evening. If the individual data are computed, the correlation between % body fat and % energy-expenditure in the evening is $r = 0.297$ ($p < .05$), whereas the correlation between % body fat and % expenditure for military activities is $r = 0.423$ ($p < .01$).

As can be seen in table 4 the compulsory military program accounts for ± 70 % of the calories expended in activities (excluding resting metabolism which cannot be influenced much !) For the lean group this is 67 %; however 73 % for the fat group.

The training program of the NCO-group during the 8 weeks has been divided roughly into non-active (mainly sitting) and active (non-sitting) lessons.

Table 6. Non comm. officers: % division of active vs. non-active lessons
100 % = total energy-expenditure of daily military activities

	non-active lessons	active lessons	total
TIME (in %)	31	69	100
ENERGY-EXPENDITURE (in %)	9.5	90.5	100

The non-active lessons account for less than 10 % of the energy-expenditure. However, they constitute more than 30 % of the time spent in military activities.

Therefore an increase in the compulsory military activities (with regard to the % energy-expenditure) is worth considering. Especially for the fat ones.
After all, there still is a linear relation between body weight and calorie-expenditure during activities.

DISCUSSION AND CONCLUSIONS

The computation of calorie-balances seems to be a difficult one. Widdowson et al. found in British cadets a positive gap between intake and expenditure: 54 vs. 50 kcal per kg body weight per day (8). This gap was bridged 1 year later by these investigators (5). However, only for groups, not in individuals.

In the previous study on Dutch Navy-recruits a positive gap between intake and expenditure has also been found: 57 vs. 46 kcal per kg body weight per day. The intake seemed however adequate as there was a decrease in body weight of 0.9 kg and a decrease in % body fat of 1.2 % at the end of the 9 week training. In the NCO-group, the gap was even greater: 54 vs. 37 kcal per kg body weight per day. The group has been in the Navy for ± 5 years and has increased 13 kg in weight, 5 kg of which are accounted for by an increase in fat mass. This weight increase is equal to a gap of less than 1 kcal per kg body weight per day.

As yet, we have not been able to explain this gap sufficiently. Nevertheless, in the event of some underestimation of the metabolic cost of the activities and some overestimation of the food intake, it is believed that military activities in general, in the Netherlands, do not justify high rations. A standard ration of 3000 kcal may be on the high side, if the extensive private consumption of snacks (and eventually alcohol) is also considered. This excludes of course specialized military groups with heavy activities.

LITERATURE

1. W.F. van Marion, G.B. Post, R. Luyken and J.C.A. Zaat, Food intake and the effect of a period of first military training on body composition of Naval and Marine recruits.; in J.F. de Wijn and R.A. Binkhorst (eds.): Nutricia Symposion on Nutritional Aspects of Physical Performance. 1972. p. 117-123.

2. Spitzer-Hettinger Tafeln für den Kalorienumsatz bei Körperlicher Arbeit. 4e Aufl. Darmstadt, Beuth Vertrieb. 1964.

3. J.V.G.A. Durnin and R. Passmore. Energy, work and leisure. London, Heinemann, 1967.

4. C.F. Consolazio, R.E. Johnson and L.J. Pecora Physiological Measurements of Metabolic Functions in Man. New York, Mc Graw-Hill, 1963

5. O.G. Edholm, J.G. Fletcher, E.M. Widdowson and R.A. McCance The energy expenditure and food intake of individual men. Brit. J. Nutr. 9 (1955) 286-300.

6. O.G. Edholm, J.M. Adam, M.J.R. Healy, H.S. Wolff, R. Goldsmith and T.W. Best. Food intake and energy expenditure of army recruits. Brit. J. Nutr. 24 (1970) 1091-1107.

7. Energy and Protein Requirements. Report of a Joint FAO/WHO Ad Hoc Expert Committee. WHO Techn. Rep. Ser. No. 522, Geneva 1973 p. 28-29

8. E.M. Widdowson, O.G. Edholm and R.A. McCance. The food intake and energy expenditure of cadets in training. Brit. J. Nutr. 8 (1954) 147-155.

THE IMPACT OF LOW CALORIC
FEEDING DURING EXERCISE

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Recent emphasis on the mobility of our military forces under conditions where resupply is difficult has created new problems in providing sufficient food and water for combat personnel to maintain adequate performance. The soldier in combat situations for periods up to 10 days must carry his pack, radio equipment, weapons, and an adequate supply of food and water, which is usually quite heavy and bulky. For years the military has been concerned about the minimal food intake necessary for effective maintenance of physical efficiency for varying periods where resupply is impossible.

Complete starvation and calorie restriction have also been utilized by food faddists ("to clean out the body"), by athletes (to make weight in a lower wrestling classification), and by the general population as a means of body weight reduction. These practices are condemned except when under the supervision of a competent physician, because of the "risk factors" that may occur.

Many abnormalities are associated with long-term starvation and semi-starvation. Canadian POW's who had been on restricted intakes in camps in Singapore and Hong Kong during World War II were studied more than 10 years after being released (1). Some of the frequent symptoms observed included easy fatigability, profuse sweating for no apparent reason, numbness and cramps in the calf muscles, loss of ambition, poor vision, edema, dyspnea on even the slightest exertion, depression, tachycardia, anorexia, nausea, restlessness, irritability, and insomnia.

Although marginal nutrition and malnutrition have been known to impair performance, the extent that work capacity and work productivity are altered in the chronically malnourished individual is largely unknown. Relatively few studies have been done on diets ranging between 0 to 2000 kcalories/day, which have been advocated for weight reduction in obesity. In a number of studies, it has been shown that the addition of well-balanced meals given to malnourished individuals has resulted in an increase in work productivity. Stearns (2) studied Costa Rican natives working on the Pan Am Highway during World War II and showed that their working efficiency and productivity improved greatly with the addition of well-balanced meals. Keller and Kraut (3) reviewed the German World War II data on industrial performance and restricted food intakes and reported that after the food intake of coal miners decreased by 400 kcal in 1946, the coal production per ton was also decreased. The same decrease in food intake also resulted in a decreased work production of steel workers. However, an increase in food allowances of the POW's in Germany resulted in a proportional increase in work production (3).

The long-term calorie restriction study of Keys et al. (4), in young adults demonstrated the detrimental effects that may occur. The consumption of one-half of the daily calorie allowances to maintain body weight resulted in a 25% body weight loss in 26 weeks (Fig. 1). Physical work performance and muscular strength were greatly reduced and did not return to normal until 24 weeks of rehabilitation. Blood hemoglobins and hematocrits were significantly reduced during the restriction period (hemoglobins from 15.1 to 11.7 gm/100 and hematocrits from 46.8 to 36.4% (Table 1)). This suggested that body protein was being catabolized.

Short-term starvation and calorie restriction have also been investigated (5-8). In one study by Henschel et al. (8), four days of fasting resulted in an increase of heart rate and minute volume with a decrease in mechanical efficiency (8). Physical fitness scores were decreased by 40%. It was suggested that when rapid body weight loss exceeded 10%, deterioration of physical work capacity occurred (due to increased anemias and cardiovascular deficiencies).

As a result of limited information on normal humans, our laboratory conducted three studies on starvation and calorie restriction (for 10 days) to evaluate any metabolic changes that may occur. The experimental designs are shown in Table 2.

In the first study, 6 healthy adult males between the ages of 21 and 52 years starved for 10 days. Water was available ad libitum at all times (5).

In the second study the subjects were 8 young male volunteers who engaged in an intensive physicel training program prior to the beginning of the study (6). The study was then divided into 3 phases, a control period of 8 days, a 10-day period of caloric restriction, and an 8-day rehabilitation period. The subjects were randomly divided into 2 groups. Group I received no supplementation and Group II received mineral supplementation. The diet used during the restriction period contained 420 kcal/day of carbohydrate. Energy expenditure was maintained at the 3200 kcal/day level.

In the third study the subjects were again 8 young male volunteers who were assigned to two groups of four men (7). The study consisted of three phases, (a) a control period of 8 days, in which the men consumed 3600 kcal/day, (b) 10 days of caloric restriction on a 500 kcal/day diet containing 85 gm of carbohydrate and 40 gm of protein and (c) 8 days of rehabilitation on a control diet of 3600 kcal/day. Energy expenditures were maintained at the 3600 kcal/day level in the study.

The major problems encountered during 10 days of complete starvation were (a) large body weight losses, (b) highly negative water balances resulting in great body hypohydration, (c) negative nitrogen balances indicating that excessive body protein was being catabolized, (d) marked ketosis, (e) large mineral losses, and (f) abnormal ECG's in all subjects during the experimental phase.

Losses of body water, body protein, and electrolytes have been shown to decrease mental efficiency, morale, ambition and initiative. The marked ketosis observed in this study (5) is attributable to carbohydrate rather than a caloric deficiency. Some studies in the literature have suggested that the undesirable effects of semi-starvation could be reduced or prevented with a low calorie antiketogenic diet (9-11). Gamble (9) demonstrated a sparing effect of glucose upon nitrogen, water and sodium excretion. He observed that ingestion of 100 gm of carbohydrate reduced body protein losses to 50 percent from starvation (from 80 to 40 gm of protein/day), with a subsequent reduction in body water. Bloom (12) reviewed most of this earlier work and concluded that carbohydrate metabolism was intricately involved in the regulation of salt and water metabolism.

As a result the second study was designed to minimize protein catabolism, decrease electrolyte excretion, eliminate ketosis, and maintain water balance by feeding a small quantity of carbohydrate (100 gm) and to observe the effect of mineral supplementation upon these metabolic factors. In this study, although nitrogen balances were not as negative as 10 days of complete starvation, they were still large, indicating that the effects of limited carbohydrate upon reducing protein catabolism was minimal. Mineral supplementation under these conditions did not affect nitrogen balance (6).

After three days of carbohydrate alone, mineral losses were reduced drastically, showing the rapid adaption to the absence of dietary minerals. Although ECG's were normal in all men, EEG's were abnormal in all men who did not receive mineral supplementation. From the observed data, ketosis was completely eliminated with only 420 kcal/day, and it was apparent that mineral supplementation was very beneficial in sparing water and in maintaining mineral balances and normal EEG patterns. However, protein catabolism was high in both groups suggesting that these low intake levels were inadequate for active individuals, even for short periods of time.

The third study on subjects consuming 500 kcal/day (including 40 gm of protein and 85 gm of carbohydrate) was designed to minimize protein catabolism, maintain water and electrolyte balance and prevent ketosis. This was based on the work of McCracken, et al. (13), who showed that small quantities of dietary protein (40 gm) reduced protein catabolism in several patients receiving 600 kcal/day as carbohydrate. Although body water was again greatly spared in this study, nitrogen balances were again negative, indicating that this was the best balance attainable under these conditions (7).

These three studies are summarized in Fig. 2 body weights, Fig. 3 fluid balance, and Table 3 nitrogen balances.

During complete starvation the total body weight loss average 7.27 kg or 9.5% of the body weight. Within 2 days the average body weight gain was 3.94 kg indicating a large hydration effect. Although the body weight losses in the 420 kcal/day study were large for both groups during caloric restriction (8% for Group I and 5.9% for Group II), they were less than 9.5% body weight loss observed during complete starvation. In the 500 kcal/day study the body weight losses averaged 8.1 and 7.2% of the initial body weights. These larger body weight losses were due primarily to the fairly high daily expenditure and subsequent calorie deficit that occurred. The body weight losses are more in the range observed by Taylor, et al. (4) whose subjects averaged 7% decrease in body weight on a 580 kcalorie intake of carbohydrate for a 12-day period. Taylor's data indicate some beneficial effect of water retention on a carbohydrate diet alone. In our study, the beneficial effect of mineral supplementation in retaining water was apparent, since Group II lost less body weight than Group I during the caloric restriction period. The beneficial effects of small quantities of carbohydrate in retaining water have also been confirmed by others.

The fluid balances were highly negative during starvation, averaging 318 gm/day for the 10-day period. Hydration was large during the first four days of rehabilitation. This was not unexpected since mineral supplements were not given during starvation and water is closely associated with body glycogen, and body protein. The body hypohydration in the 420 kcal/day study during days 1 and 2 of caloric restriction for Group I is obvious, but these losses were still considerably less than observed during complete starvation, indicating some sparing of water with small quantities of carbohydrate. However, these losses during caloric restriction, were considerably less in Group II, indicating some additional beneficial effects of water retention by mineral supplementation.

In the 500 kcal/day study body water losses were minimal, the greatest water loss being observed in Group I during days 1 to 4 of restriction. The very limited water loss in Group II during restriction is strongly indicative of the beneficial effects of mineral supplementation and the small quantities of carbohydrate and protein being consumed. Rogers et al. (10) have also reported that the supplementation of sodium salts during fasting would reduce ketonuria and hypoglycemia and also minimize body hypohydration as indicated by a lesser weight loss.

The body water loss may have been due to some voluntary hypohydration since the fluid intakes from all sources were decreased during the restriction period; however, other factors such as increased urine volumes and decreased urine specific gravities during caloric restriction do not substantiate this concept. These factors are all indicative of an adequate water supply. Forced ingestion of fluids (10, 13) has not been found to be beneficial in decreasing the hypohydration effect; in fact, it only contributed to an increased urine volume as was observed in our study.

Blood, plasma and red blood cell volumes followed the same hypohydration pattern in both groups being significantly decreased (Fig. 4). Decreases in plasma volumes during starvation are not unusual, having been reported by other investigators (14, 16, 17).

The observation of a decreased plasma volume during fasting is consistent with the negative water balance that occurred. It is the general opinion that during fasting, the extracellular fluid volume is decreased and, as a result, one would expect a proportional decrease in plasma water and an overall decrease in blood volume. Higher osmolalities and the equilibrium of osmotic pressure would make the concomitant excretion of minerals and body water obligatory. An increase in fluid intake, as was observed, could accommodate the large quantities of minerals and urea being excreted, without causing a negative fluid balance. The decrease in urinary solids, due to decreased urea formation and salt excretion, indicated a reduction in the obligatory loss of water (9, 18) and this prevented ketosis.

Nitrogen balances did not include any estimates of the sweat losses which would have resulted in larger negative balances. THe greatest nitrogen loss occurred during starvation, averaging 8.5 gm of nitrogen/day or 54 gm of protein. In the 420 and 500 kcal/day studies, the nitrogen losses were lower than in complete starvation, indicating that limited carbohydrate and protein, with and without mineral supplementation, did prevent some body catabolism. These differences were not quite as high as the 50 percent reduction reported by Gamble (9) when he compared starvation and an intake of 400 kcalories of carbohydrate. Quinn, et al. (15), also observed no beneficial effect or improvement of negative nitrogen balances on intakes up to 900 kcal/day. Their subjects showed a negative nitrogen balance of 7.3 gm/day for the nine-day study, equivalent to 45.6 gm/protein loss/day.

The great losses of total nitrogen in urine, during caloric restriction, are all indicative of catabolism of body protein for gluconeogenesis and energy. The subsequent decrease of these substances toward the end of the 10-day period, indicate some adaptive mechanisms for conserving body protein. Whether or not these losses of nitrogen are significant in decreasing physical efficiency of the individual is questionable. Some studies have suggested that ths body has labilo stores or protein reserves which are readily lost during adaptation to low protein or low calorie diets.

Physical work capacity was measured at these levels, submaximal (3.4 mph on a 4% grade), maximal (3.4 mph with a 1% grade rise/minute, until exhausted) and a stamina test (4.0 or 4.5 mph on a 10% grade for 60 minutes).

Pulmonary ventilations, heart rates, maximal work times and oxygen uptakes in ml/k g/min were essentially unchanged during the entire restriction periods (Table 4, 5, Fig. 5). Since the data suggested abnormalities of hypohydration and protein catabolism, this implies that a sustained caloric deficit would eventually result in a decrease in work capacity as observed in the Keys et al. (4) study. Calorie restriction did not produce a decrease in performance in the stamina test, even when the body glycogen stores should have been depleted.

In the 420 and 500 kcal/day studies the unimpaired performance could be partially attributed to the loss of excessive body fat, the effect of the carbohydrate and mineral supplemented diets, that reduce the body weight and body water losses. These factors acted as a protective mechanism in maintaining maximal efficiency.

Other significant findings during starvation were decreased diastolic pressures which suggest decreased cardiovascular activity, and this appears to be an adaptive mechanism to conserve energy.

The electrocardiograms taken during the last day of fasting were abnormal. The AVF and the QRS axis changes were significantly different from the controls and were considered to reflect the effects of a severe stress. In the Keys, et al. (4) study, the significant changes were also reported in the electrocardiograms. These changes which reached their maximum at 12 weeks of semi-starvation, included "an increase of the QT interval, a continuous decrease in amplitude of all deflections, and marked shifts to the right of the QRS and T axes." As in our study, these changes all returned to normal after rehabilitation.

The data suggest that calorie restriction from 0 to 500 kcal/day should not be recommended due to the significant metabolic and cardiovascular abnormalities that occur.

The field test in Panama was a continuation of the calorie restriction studies. The objectives of this study were to (a) determine the minimal caloric intake that would present unacceptable loss of mental and physical performance of men on maneuvers; (b) obtain some measure of the decrement in performance after various periods (up to 10 days) of reduced caloric intake, and (c) test a compact ration. The laboratory studies were quite adequate for the preliminary observations; however, to evaluate the effects of reduced intake under combat patrol activities, a more realistic environment and military physical activities were utilized. The use of soldiers performing strenuous training maneuvers provided information that was more applicable for making recommendations since a measure of any decrement in performance would provide information to officers regarding the planning of such maneuvers in combat situations.

In this study, four levels of calorie intake were evaluated on troops acclimated to a tropical environment.

The daily food intakes averaged 603, 947, 1362, and 3301 kcal/day for the 10-day restriction period (Table 6). Protein intakes were low for the restricted groups averaging 34.1, 34.7 and 54.4 gm/day for groups I, II and III. The nitrogen deficit exclusive of the sweat losses averaged 3.29 and 2.78 gm/day for groups I and II (or 206 and 174 gm protein for 10 days).

Hemoblobins in tha Panama study were essentially unchanged for all groups during the entire experimental phase (Table 7). However, serum proteins were significantly different from controls for Groups I, II and III (the restricted groups) during the same experimental period, suggesting catabolism of body protein. The group consuming a normal diet had serum protein values that were essentially unchanged from control values.

Maximal work capacity measurements included maximal work time in minutes, heart rates and oxygen uptakes in ml/kg/min. These parameters, in general, were not significantly different from control values in all groups (Table 8), suggesting no decrement in performance during the 10-day restrictive period.

Tha data suggest that daily intakes between 600 to 1400 kcal/day may have been adequate in maintaining physical efficiency during short-term restriction, however, the significant losses of serum protein in the restricted groups suggest that some protein catabolism occurred and this may be detrimental if continued for longer periods of time.

The British Army study in Malaysia in 1970 was designed to reaffirm the 1967 British test that determined that men could maintain military efficiency when fed a suboptimal diet (20). Two dehydrated rations were evaluated — one at a normal daily calorie intake level of 3,500 kcal/day, and the second at a calorie restricted level of 1,800 kcal/day. The primary objective was to evaluate these rations as they would affect the military efficiency of troops during maneuvers in a hot jungle environment. The secondary interest was to evaluate the nutrient losses in sweat under conditions of great water intakes and sweat losses.

Thirty-two young men from the Hong Kong garrison were divided into two groups of 16 men each -- one-half receiving the normal ration (Group I), and the other half receiving the restricted ration (Group II). Three men were hospitalized early in the study and were eliminated. This resulted in Groups I and II having 14 and 15 men, respectively.

The study consisted of a): a 10-day heat acclimatization and training phase in which the men adjusted to the heavy physical activity in the hot, humid Malaysian environment; b) a 3-day control period; c) a 12-day experimental period in which the men bivouacked in the field and ate the experimental ration, and d) a 9-day rehabilitation period.

Food intakes averaged 2974 and 1750 kcal/day for the two groups during the 12-day experimental phase (Table 9). Protein intakes averaged 79.8 and 55.6 gm/day for the same respective groups (1.12 and 0.80 gm/kg body wt). Body weight losses were high, averaging 2.39 and 3.90 kg for Groups I and II respectively. The body weight loss in the normal Group I was apparently due to the unacceptability of the assault ration. The men consumed 500 kcalories less than the 3500 kcalories offered.

Group I nitrogen differences (exclusive of fecal nitrogen losses) were positive averaging a +1.6 gm/day during the entire restriction phase. However, the values for Group II showed the opposite, being negative and averaging a -2.28 gm/day for the entire test phase (Table 10). Although nitrogen intakes were considerably higher for Group I during the experimental period (80 and 56 gm/day of protein), the average urinary nitrogen excretions were not significantly different between groups. There appeared to be no significant decreases or adaptation in nitrogen excretion with continued calorie restriction of 12 days. However, the daily sweat secretions increased as the experimental period progressed. By days 10-12, the sweat losses increased from 2.10 to 3.17 gm/day for Group I and from 2.51 to 3.01 gm/day for Group II. Although the daily nitrogen intakes of both groups were quite different, the sweat secretions were essentially the same (Table 10).

The blood hemoglobins, hematocrits and serum protein data were not significantly different from control values during the 12-day experimental period (Table 11), and although both groups were in negative water balance during the experimental phase, hemoconcentration was not apparent at 12 days. The greatest portion of the hypohydration occurred within the first 3 experimental days.

Physical work capacity parameters were essentially unchanged from controls for each group and essentially unchanged between groups, suggesting limited effects of short-term calorie restriction on work performance. The data suggested that men could operate adequately on approximately one-half (1750) kcalories under conditions of heavy physical activity with profuse sweating.

SUMMARY

A mild case of calorie deficiency in humans is fairly difficult to diagnose, but the severity of a bad case of calorie deficiency is usually observed by a large body weight and body water loss, the rapidity of the weight loss, and other associated findings of calorie restriction including a negative nitrogen (or protein) balance, an anemia, a low-fasting blood sugar level and a decrease in basal metabolic rate.

Chronic dieting or under nutrition, as observed during body weight reduction may have other deleterious effects. A combination of water and food restriction makes normal renal function even more difficult since it imposes increased demands for body waste elimination. This could result in a retention of urea and the development of uremia. Body weight loss must be made only at the expense of stored and excessive body fat and not water, since clinical damage (protein catabolism) can also occur. For example: during training the initial body weight loss is due to a loss of body fat and the elimination of some tissue fluids. During continual training the process may be reversed since the person may gain body weight due to the increase in body protein or muscle mass.

With calorie restriction below 1000 kcalorie/day, body fat and protein must be utilized as energy sources since the maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. Low antiketogenic diets with adequate mineral intakes can prevent ketosis, minimize protein catabolism, maintain fluid balance and decrease the electrolyte excretions.

Short-term calorie restriction did not reduce performance in the endurance test even when the body glycogen stores should have been depleted. Maximal work capacities were also not impaired, even though body hypohydration and protein catabolism occurred during the 10-12 days of restriction. However, a sustained calorie deficit would eventually lead to a decrease in physical work capacity, as in the Keya et al. study (4).

The best restricted diet (short term 10-12 days) must contain a minimum of 1400 kcalories/day. It should be acceptable, one that the person enjoys eating, and should provide the daily allowances of all the essential vitamins and minerals. The diet must contain a minimum of 100 gm carbohydrate and the daily NRC protein allowances of 0.8 gm/kg body weight.

REFERENCES

1. Coke, L.R. Med. Serv. J. Canada. 17: 313. 1961
2. Stearns quoted by F. Lowenstein. FAO, WHO. Food and Nutrition in Africa. No. 6. p. 17. July 1968.
3. Kellar, W.D. and Kraut, H.A. Work and Nutrition. World Review of Nutrition and Dietetics. Vol. 3. Pittman Publ. Great Britian. 1963.
4. Keys, A., Brozek, J., Henschel, A., Mickelsen, O. and H.L. Taylor. The Biology of Human Starvation. Univ. of Minnesota Press. Minneapolis, MN. 1950.
5. Consolazio, C.F., L.O. Matoush, H.L. Johnson, R.A. Nelson and H.J. Krzywicki. Amer. J. Clin. Nutr. 20: 672. 1967.
6. Consolazio, C.F., L.O. Matoush, H.L. Johnson, H.J. Krzywicki, G. J. Isaac and N.F. Witt. Amer. J. Clin. Nutr. 21: 793. 1968.
7. Johnson, J.L., C.F. Consolazio, H.J. Krzywicki, G.J. Isaac, and N.F. Witt. Amer. J. Clin. Nutr. 24: 913. 1971.
8. Henschel, A., H.L. Taylor and A. Keys. J. Appl. Physiol. 6: 624. 1954.
9. Gamble, J.L. Proc. Amer. Phil. Soc. 88: 151. 1944.
10. Rogers, T.A., J.A. Setliff and A.C. Buck. Arctic Aero Med. Lab., Aerospace Medical Division, Fort Wainwright, AK. 1965.
11. Winkler, A.W., T.S. Danowski, J.R. Elkington and J.P. Peters. J. Clin. Invest. 23: 807. 1944.
12. Bloom, W.L. Amer. J. Clin. Nutr. 20: 157. 1967.
13. McCracken, B.H., M.A. Pearl and E. Carvaja. New England J. Med. 20: 1050. 1965.

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14. Taylor, H.L., A. Henschel, O. Mickelsen and A. Keys. J. Appl. Physiol. 6: 613. 1954.

15. Quinn, M., C.R. Kleeman, D.E. Bass and A. Henschel. Metabolism. 3: 68. 1953.

16. Rappoport, A., G.L. From and H. Hudson. Metabolism. 14: 31. 1964.

17. Bloom, W.L., G. Azar and E.G. Smith, Jr. Metabolism. 15: 401. 1966.

18. Harvey, A. and N. Lasker. Clin. Res. 11: 243. 1963.

19. Studies in Tropical Environments - Panama 1970. In Press.

20. Studies in Tropical Environments - Malaysia. In Press.

TABLE 1

LONG-TERM SEMI-STARVATION (KEYS ET AL.)

BIOCHEMICAL ASPECTS*

	Control	Phase Restriction Weeks 12	24	Rehabilitation, Days 6	12
Hemoglobin, g/100	15.1	12.6	11.7	12.3	12.8
Hematocrit, %	46.8		36.4		40.2
Serum Protein, g/100	6.7	6.4	6.0	6.1	6.4
Uric Acid mg/100	3.9		2.8		
Blood Volume, Liters	5.30		5.22		4.80

* Nitrogen intakes averaged 7.8 g/day during restriction, balances were negative by 1.0/day (exclusive of sweat losaea).

TABLE 2

CALORIE RESTRICTION STUDIES, 10 DAYS*

EXPERIMENTAL DESIGN

Study I	Starvation, 6 men, Age 21-52 years
	Expenditure 2800-3000 kcal/day
Study II	Restriction 420 kcal/day - All Carbohydrate
	Group I No Supplements - 4 men
	Group II Mineral Supplements 4 men
	Expenditure 3200 kcal/day.
Study III	Restriction 500 kcal/day (85g carbohydrate and 40g protein)
	Group I No Supplements - 4 men
	Group II Mineral Supplements 4 men
	Expenditure 3600 kcal/day

* Water ad libitum in all studies. No vitamin supplements.

TABLE 3

NITROGEN BALANCES, g/MAN/DAY RESTRICTION STUDIES (USAMRNL)*

Phase	Starvation	420 kcal Group I	420 kcal Group II	500 kcal Group I	500 kcal Group II
Control					
6 days, g/day	0	+4.78	+4.51	+1.75	+0.65
Restriction					
Total gm Nitrogen Lost, 10 days	-85.0	-62.0	-60.8	-60.6	-54.9
Rehabilitation					
Total gm retained, 8 days		+43.22	+42.86	+20.82	+24.20

* These balanced do not include sweat losses.

Group II Mineral Supplemented.

TABLE 4

CALORIE RESTRICTION

WORK TIME IN MINUTES (MAXIMAL)

Phase	Starvation	420 kcal.		500 kcal.	
		I	II	I	II
Control	20.8	18.8	20.6	18.8	18.5
Restriction, Days					
1	18.9				
4	20.5			17.2*	17.9
5		18.7	21.6		
7	22.2				
9		17.9	19.9		
10	20.7			17.9	18.9
Rehabilitation	23.4	17.9	20.1	18.4	19.8

* Significantly different from control phase.

Group II Mineral Supplemented.

TABLE 5

CALORIE RESTRICTION

HEART RATES/MIN. MAXIMAL WORK

Phase	Starvation	420 kcal. I	420 kcal. II	500 kcal. I	500 kcal. II
Control	196	190	194	178	177
Restriction, Days					
1	197				
2		188	190	177	176
4	189				
5		184*	187	176	175
7	186				
8		180*	182*	177	176
10	183				
Rehabilitation	177*	180*	182*	178	180

* Significantly different from control phase.

Group II Mineral Supplemented.

TABLE 6

PANAMA - TROPICAL

NUTRIENT INTAKES/DAY*

Nutrients	GROUPS 1	2	3	4
K Calories	603	947	1362	3301
Protein, g.	34.1	34.7	54.4	142.0
Protein g/kg body wt.	0.48	0.48	0.69	2.00
Body weight changes kg. 10 days	-3.22	-2.92	-2.92	-0.57
Nitrogen deficit exclusive of sweat losses g/day	-3.29	-2.78	+0.33	-

* 10 day restriction periods.

TABLE 7

PANAMA - TROPICAL

	GROUP			
	1	2	3	4
Hemoglobins g/100				
Control	14.8	15.3	15.2	14.5
Day 4	14.7	15.6	15.2	14.8
Day)	14.8	15.3	14.8	14.6
Serum Proteins G/100				
Control	6.6	6.9	6.3	6.4
Day 4	6.3	6.5	5.8*	6.1
Day 10	6.0*	6.3*	5.6*	6.3

* Values are significantly different from controls.

TABLE 8

PANAMA

MAXIMAL WORK CAPACITY PARAMETERS*

	Control	Restriction Day 3	Restriction Day 9	Rehabilitation Day 4
Work Times Min				
I	20.7	19.1	20.8	20.2
II	22.3	20.0	22.7	22.5
III	22.5	20.7	21.3	21.4
IV	22.1	21.2	20.8	21.2
Heart Rates/Min				
I	188	190	192	188
II	188	186	190	191
III	190	189	189	188
IV	194	188	187	184
Oxygen Uptakes, ml/kg/min				
I	43.6	40.4	40.8	40.2**
II	43.7	42.9	43.2	45.2
III	42.8	41.1	40.9**	41.9
IV	42.6	42.2	42.0	41.6

* Balke test, 3.5 mph with grade increased 1%/min. until exhaustion.

** Significantly different from controls at $p<.05$.

TABLE 9

MALAYSIA 1970

NUTRIENT INTAKES/DAY*

	British Assault Ration	Australian Dehydrated
k calories	2974	1750
Protein, g	79.8	55.6
Protein, g/kg Body Weight	1.12	0.80
Fat, g.	107.9	45.4
Carbohydrate, g.	438.0	276.0
Body Weight Changes, kg/12 days	- 2.39	- 3.90

*Mean of 14 mean in each group.

TABLE 10

MALAYSIA: SUMMARY NITROGEN DATA, gm/DAY

	Intake	Output		Difference
		Urine	Sweat	
GROUP I				
Control	16.12	9.81	0.76	+5.55
Restriction				
Days 1-12 mean/day	12.76	8.47	2.68	+1.61
GROUP II				
Control	14.45	11.66	0.60	+2.19
Restriction				
Days 1-12 mean/day	8.90	8.40	2.78	-2.28

* These values do not include fecal nitrogen losses.

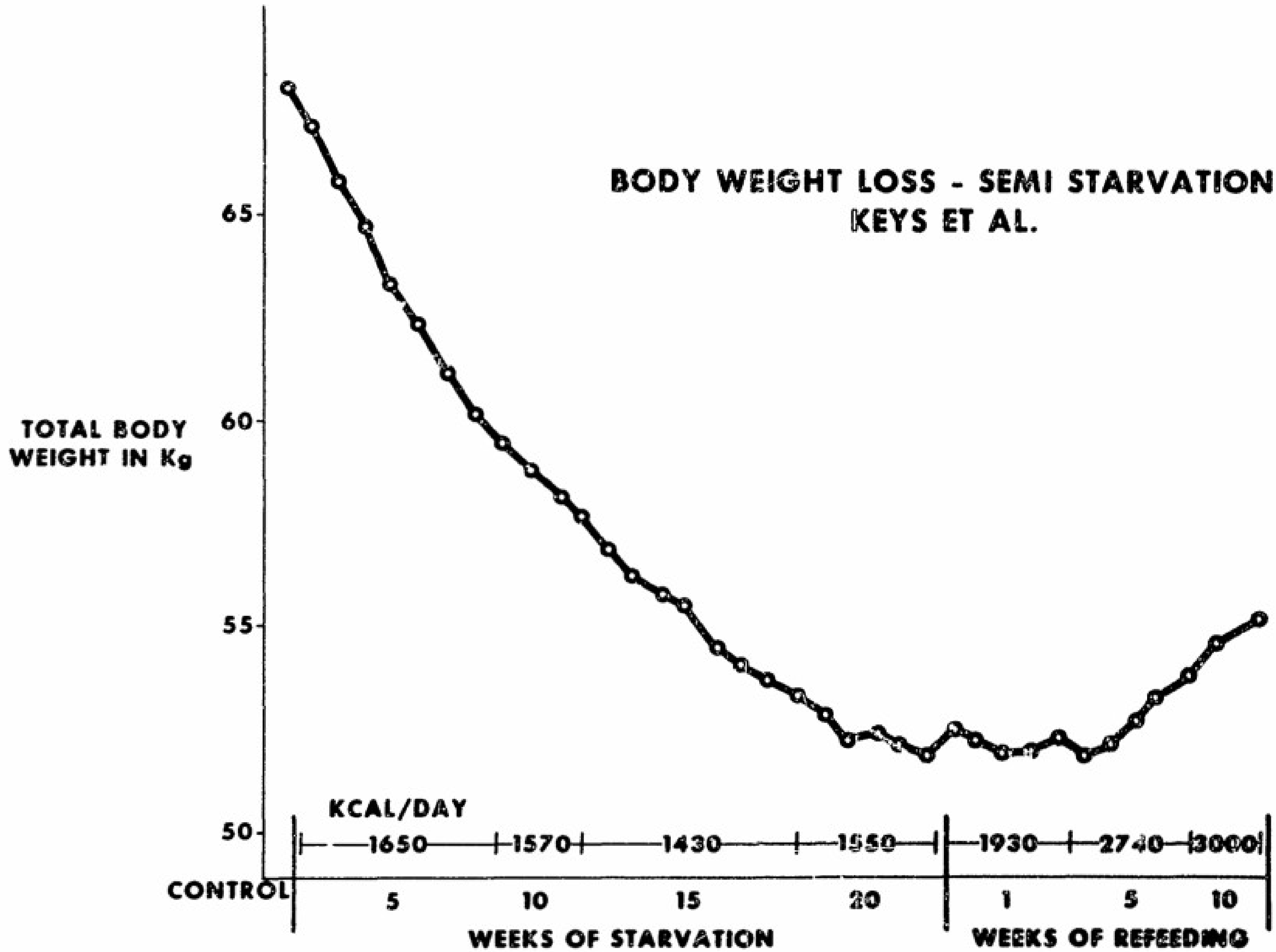
TABLE 11

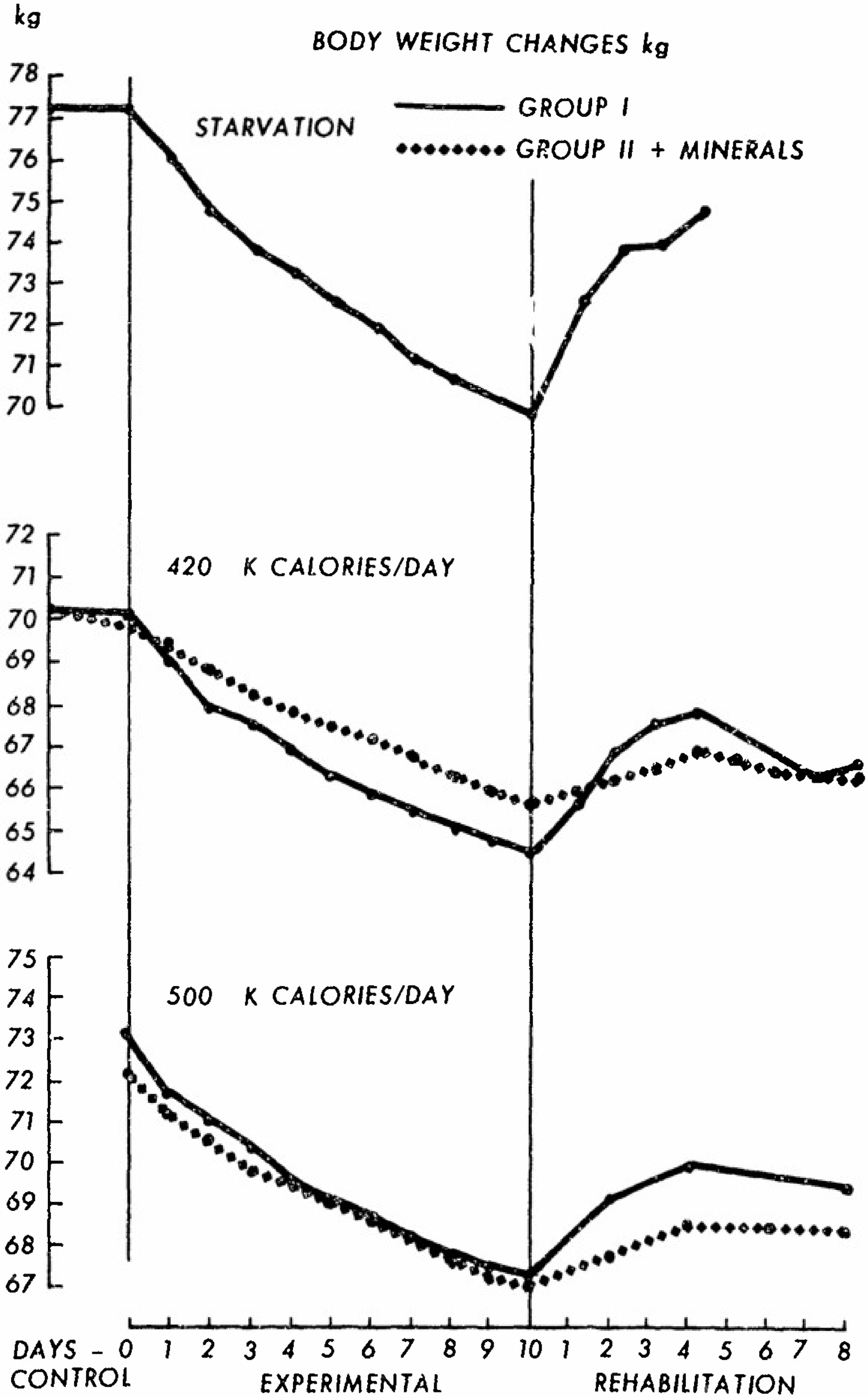
MALAYSIA 1970

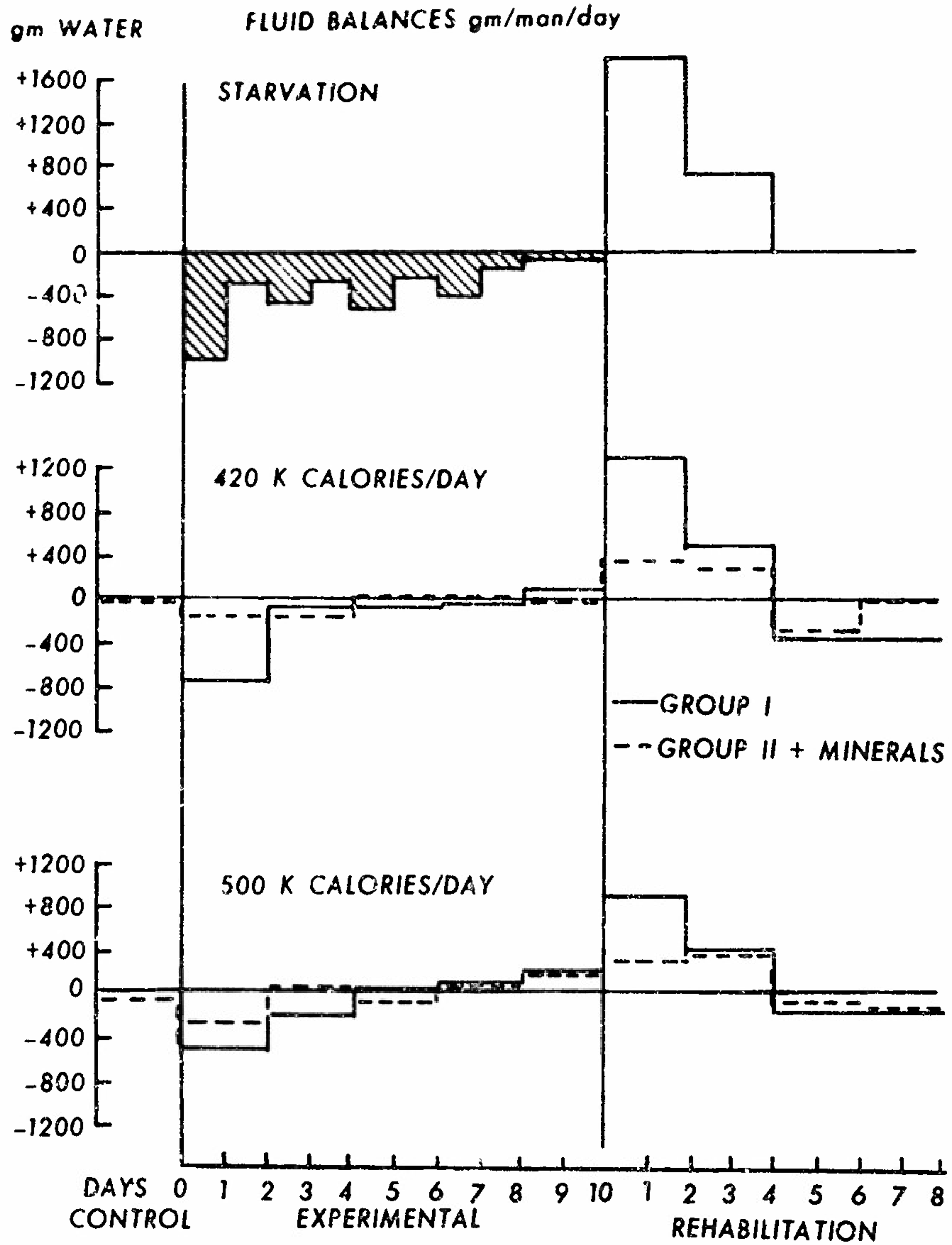
FASTING BLOOD VALUES*

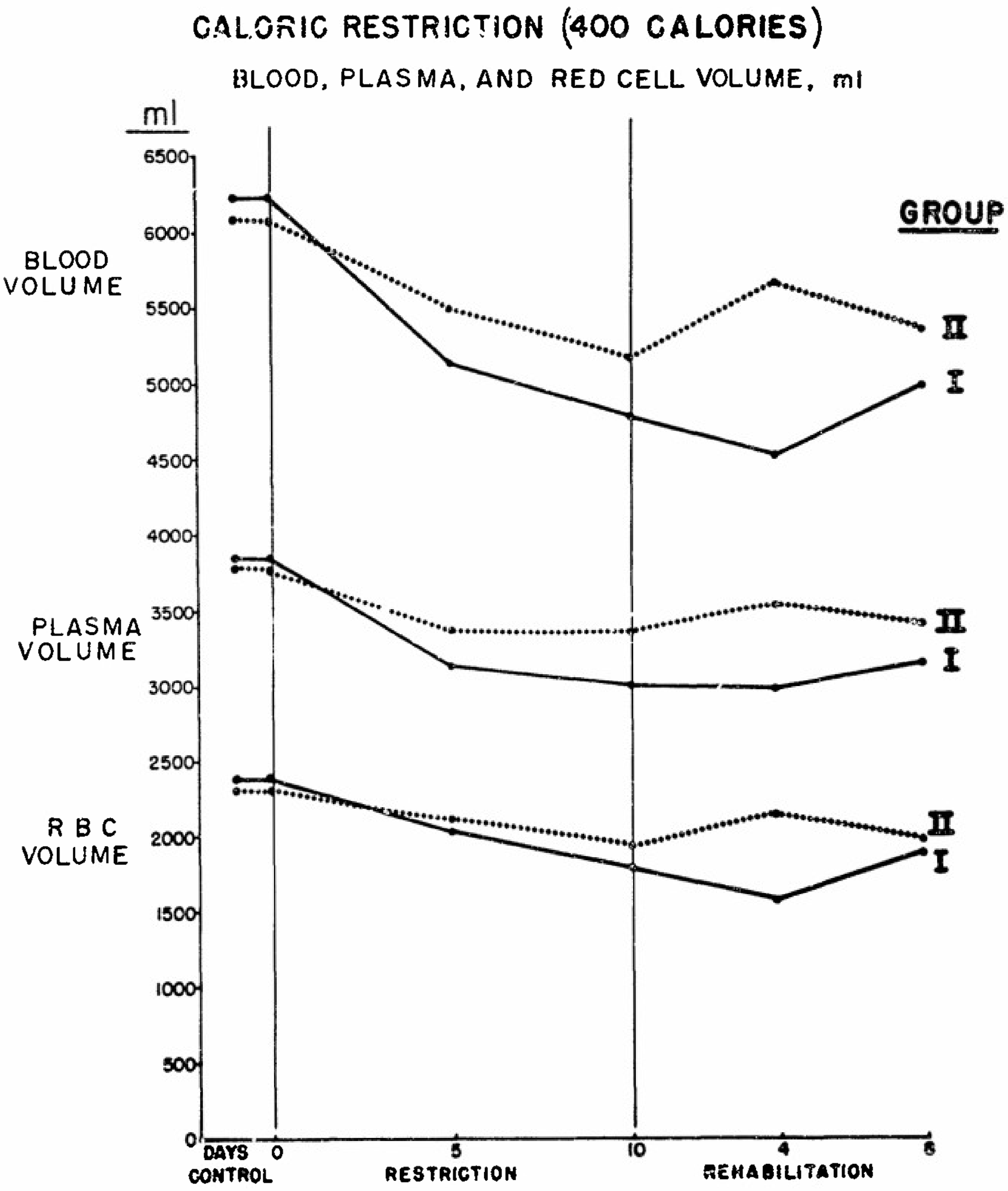
	Group I		Group II	
	Control	Restriction	Control	Restriction
Hemoglobins, g/100	15.3	15.1	14.9	14.9
Hematocrits, %	44.0	43.6	41.1	40.6
Serum Protein, g/100	6.1	6.6	6.4	6.6

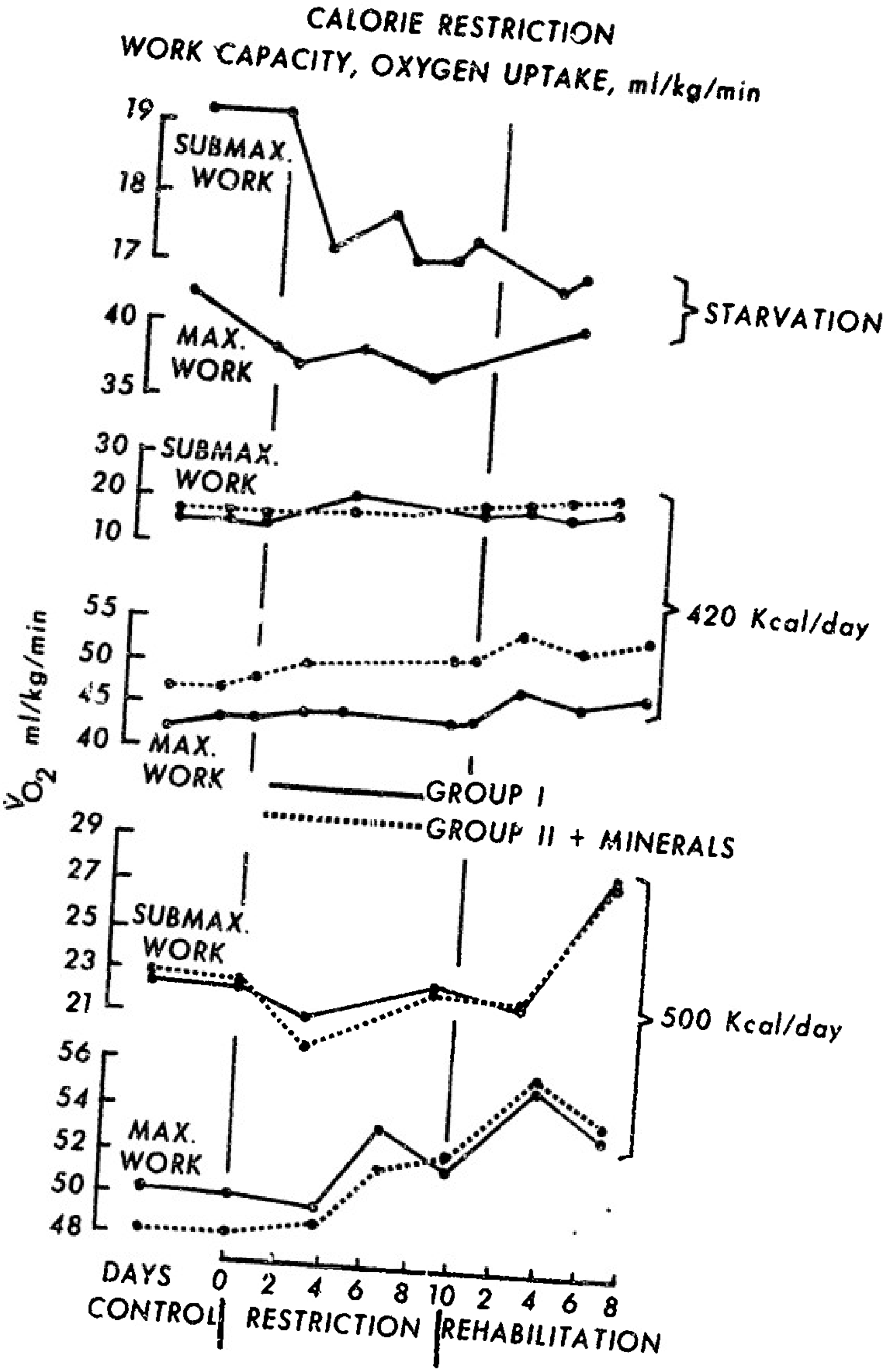
* Twelve (12) days of restriction - values were not significantly different from controls.


BODY WEIGHT LOSS - SEMI STARVATION
KEYS ET AL.
TOTAL BODY WEIGHT IN Kg
65
60
55
50
CONTROL
KCAL/DAY
1650
1570
1430
1550
1930
2740
3000
5
10
15
20
WEEKS OF STARVATION
1
5
10
WEEKS OF REFEEDING


kg
BODY WEIGHT CHANGES kg
GROUP I
GROUP II + MINERALS
STARVATION
420 K CALORIES/DAY
500 K CALORIES/DAY
78 77 76 75 74 73 72 71 70
72 71 70 69 68 67 66 65 64
75 74 73 72 71 70 69 68 67
DAYS – 0 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8
CONTROL
EXPERIMENTAL
REHABILITATION


gm WATER
FLUID BALANCES gm/man/day
+1600
+1200
+800
+400
0
-400
-800
-1200
STARVATION
420 K CALORIES/DAY
500 K CALORIES/DAY
GROUP I
GROUP II + MINERALS
DAYS 0 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8
CONTROL
EXPERIMENTAL
REHABILITATION


CALORIC RESTRICTION (400 CALORIES)
BLOOD, PLASMA, AND RED CELL VOLUME, ml
ml
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
BLOOD VOLUME
PLASMA VOLUME
R B C VOLUME
GROUP
II
I
II
I
II
I
DAYS
0
5
10
4
6
CONTROL
RESTRICTION
REHABILITATION



CALORIE RESTRICTION
WORK CAPACITY, OXYGEN UPTAKE, ml/kg/min
SUBMAX. WORK
MAX. WORK
STARVATION
420 Kcal/day
500 Kcal/day
$\dot{V}O_2$ ml/kg/min
GROUP I
GROUP II + MINERALS
DAYS 0 2 4 6 8 10 2 4 6 8
CONTROL
RESTRICTION
REHABILITATION

ESTABLISHMENT AND ASSESSMENT OF CERTAIN U. S. MILITARY NUTRIENT REQUIREMENTS

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U.S.A.

One of the tasks of the Letterman Army Institute of Research is to advise and assist the U.S. military services in matters of nutrition. The services and guidance provided aids in assurance that adequate nutrition is provided the military personnel. Some of the services provided by the Institute include the following: (a) Establish nutrient requirements and develop nutritional and dietary standards for personnel subsisting under normal and special operating conditions (arctic, desert, tropics, etc.); (b) Develop procedures for assessing nutritional status of military personnel; (c) Make periodic surveys of military personnel to determine the nutritional adequacy of the food served and as consumed and to evaluate the nutritional status of the personnel; and (d) Conduct studies on techniques for measuring body composition and provide guidance as to ideal body weight and on weight control.

This presentation will be limited largely to comments on the first two items. Aspects of the remaining items will be included in other presentations.

The Institute and the former unit, U.S. Army Medical Research and Nutrition Laboratory, have been active in studies on the establishment of nutrient requirements. Knowledge of nutritional requirements of military personnel operating under various environmental conditions is essential for the establishment of nutritional standards and for the evaluation of the nutritional adequacy of the food served. Nutritional standards, such as the Medical Services Nutritional Standards (AR 40-25) and the Recommended Dietary Allowances, have two primary uses: (a) to plan diets and rations for individuals or groups of people and (b) to evaluate the nutritional adequacy of the foods consumed.

Dietary standards are opinions based upon experimental studies specifically designed to evaluate nutrient requirements of the human and upon practical experience and information as to nutrient intakes of individuals and population groups. Such judgments must take into consideration that nutrient requirements may differ for individuals as a result of influences of factors such as age, sex, weight, activity, and environment. Since information is limited as to the degree of influence such factors have on nutrient requirements, the various dietary standards provide an allowance for these uncertainties (1). Thus, the dietary allowances are established higher than the estimated average reouirement.

In an affluent country such as the U.S.A., it is generally accepted and assumed that errors in nutrient allowances on the high side are preferable to underestimates on the actual need. Such considerations have been incorporated into the U.S. Military Nutritional Standards (2).

These standards "reflect existing knowledge on amounts of nutrients sufficient to maintain adequate nutrition of military personnel under normal conditions, and allow a margin of safety for individual variations" (2). As may be noted in Tables 1 and 2, nutrient allowances for the U.S. military personnel may exceed somewhat those recommended by the U.S. National Academy of Sciences-National Research Council (3). Calories, protein, vitamin C, and riboflavin are examples. The Japanese Recommended Dietary Allowance (Table 3) and the Canadian Recommended Daily Nutrient Intakes (Table 4) for the age 18 year old civilian population are presented for comparison.

Vitamins are recognized as nutrients essential to performing the physiological processes of the body. However, endogenous means are not available to produce them, therefore, exogenous sources must be provided. The requirements for the vitamins appear to be the results of their excretory losses in the urine and feces and through metabolic degradations.

As noted above, personnel at this Institute have conducted a number of studies designed to establish the requirement of various nutrients for the normal adult male. The nutrients studied include vitamin B-6, vitamin C, vitamin A, thiamin, and riboflavin.

Vitamin B-6 (pyridoxine) is used as an example of the type of studies conducted. The quantitative adult male human requirement for this vitamin was established by placing adult male volunteers on controlled experiments. The subjects received either formula diets or special menus that were devoid or inadequate in vitamin B-6. Table 5 provides the general composition of the liquid formula diets that were employed in the vitamin B-6 requirement studies. Similar diets were utilized in studies on the human requirement for vitamin C, vitamin A, thiamin and riboflavin. The diets permit controlled depletion and repletion of the subjects in the specific vitamin under study.

For studies on vitamin B-6 requirement, a low protein and a high protein diet were used because of the association of the vitamin to protein metabolism. The requirement for vitamin B-6 can be evaluated in the human on the basis of (a) changes in urine or serum levels of vitamin B-6; (b) erythrocyte transaminase activities; (c) response to tryptophan or methionine load tests; (d) 4-pyridoxic acid excretion; and (e) the presence of abnormal electroencephalograms (4-6).

Vitamin B-6 deficiency can be induced in the adult male within two or three weeks. In isotopic studies, we demonstrated that the body pool of vitamin B-6 is approximately 22 to 27 milligrams. The half-life of isotopically labeled pyridoxine was approximately 15 to 20 days (7). As noted in Figure 1, the urinary excretion of vitamin B-6 dropped dramatically and increased again when supplementation of the vitamin was instituted. Similarly, abnormal amounts of xanthurenic acid were excreted following tryptophan loads within two weeks after placing the subjects on the high-protein vitamin B-6 deficient diet (Figure 2). Vitamin B-6 supplementation promptly corrected the abnormal xanthurenic acid excretion. Subjects receiving the low-protein vitamin B-6 deficient diet did not reach the same degree of pyridoxine deficiency as based on urinary excretion of xanthurenic acid following a tryptophan load until the sixth week of deficiency.

Erythrocyte transaminase activities also reflect vitamin B-6 status (Figure 3) (5). This was particularly evident in the in vitro stimulation of erythrocyte glutamic oxaloacetic transaminase (EGOT) activity by pyridoxal phosphate. Thus, EGOT activity declines with inadequate intakes of vitamin B-6 and is accompanied by an increase in the percentage stimulation by pyridoxal phosphate.

The most marked clinical manifestation observed during the vitamin B-6 deficiency period in the volunteer subjects were electroencephalographic abnormalities. Electroencephalographic changes are indicated in Figure 4. Repletion of the subjects with vitamin B-6 corrected the electroencephalographic abnormalities.

From the results obtained from a series of controlled volunteer studies, it has been concluded that for the adult male human, the optimal daily vitamin B-6 requirement was 1.75 to 2.0 milligrams per day for subjects with a protein intake of 100 grams. An allowance of 2.0 milligrams of vitamin B-6 per day has been adopted as the recommended allowance by the U.S. National Academy of Sciences and the U.S. Military Services.

Similar experimental approaches have been utilized at the Institute to establish the adult human requirement for vitamin C. In these studies, adults received controlled intakes of ascorbic acid (vitamin C). Their body pools of the vitamin were followed through the use of isotopically labeled ascorbic acid (8-11). When the subjects received a diet free of ascorbic acid, their plasma and whole blood levels of vitamin C fell rapidly (Figure 5). Plasma ascorbic acid fell to levels lower than those of whole blood. Ascorbic acid disappeared from the urine early in depletion. The first signs of scurvy appeared when the plasma ascorbic acid levels ranged from 0.13 to 0.24 milligrams per 100 ml and the pool size had been depleted to a range of 96 to 490 mg from an average initial pool of 1,500 mg. Supplements of 10 mg of ascorbic acid per day were sufficient to alleviate and cure the clinical signs of scurvy in the subjects. The isotopic labeling studies permitted a measurement of the actual utilization and turnover of vitamin C in the body. The results indicated that the adult human male utilizes approximately 30 mg of ascorbic acid daily. An intake of 45 mg per day of ascorbic acid would maintain an adequate and normal body pool of vitamin C. The recent National Academy of Sciences Recommended Dietary Allowance has adopted 45 mg of vitamin C per day as the recommended allowance for the adult male. The U.S. Military Services recommend an intake of 60 mg of vitamin C which provides an allowance for stressful conditions.

The adult human male requirements for thiamin, riboflavin, and vitamin A have been investigated in a similar manner at our Institute. Some of these studies have been published in detail elsewhere (12-15).

Once nutrient requirements have been established, practical procedures are then necessary to determine whether or not these needs are being provided by the diets consumed. The nutritional status of military personnel in the U.S.A. and in over thirty foreign countries has been evaluated through the conduct of nutrition surveys. The assessments when conducted periodically can monitor changes in food usage that may result from changes in economics, food supply, feeding systems, and other factors. Such surveys generally include clinical and dental examinations, anthropometric measurements, dietary intake evaluations, and biochemical assessments.

Dietary survey information is generally subject to less accuracy than that obtained by biochemical procedures. Errors are involved in estimating the amount of different foods eaten and of their nutrient content. Moreover, an individual's pattern of food consumption may not necessarily be characterized by the diet consumed on any one day or even in one week.

In recent years, various biochemical methods and techniques have been developed for the evaluation of the vitamin nutritional status of population groups or of individual subjects. Biochemical measurements represent an objective assessment of the nutritional status of an individual and may provide pre- or subclinical information. Depending upon the measurement employed, information may be obtained as to an individual's present or recent and sometimes long-range nutritional status.

Many of these procedures have been developed at this Institute and utilized extensively in military nutrition surveys. Biochemical techniques are available for assessing the nutritional status of individuals for most of the vitamins (15). The techniques can in general be categorized as follows: (a) measurement of the vitamin under study in urine and blood; (2) measurement of a metabolite of the vitamin under study in urine or blood; (3) measurement of an abnormal metabolite resulting from a deficiency of a vitamin; (4) perform functional or load tests; and (5) measurement of the product of the vitamin under study.

The validity of the biochemical techniques have been established mainly through the use of controlled human volunteer studies as described earlier. Guidelines for the interpretation of biochemical data have also been established as the result of such investigation (15). This permits an evaluation and classification of an individual as to whether his nutrient intakes are inadequate, low, adequate, or high.

Table 6 summarizes some of the more commonly used laboratory tests that are useful for the assessment of vitamin nutritional status. For example, serum vitamin A (retinol) levels can be used to assess the nutritional status of this nutrient. Prolonged low dietary intakes of vitamin A correlate with serum concentrations of retinol. Since the vitamin is stored in the liver, low serum levels of vitamin A reflect not only low intakes of the nutrient but also depleted liver stores. Serum vitamin A levels above 30 μg/100 ml indicate liver stores of vitamin A while serum values below this generally indicate low or inadequate intakes of the vitamin.

Serum ascorbic acid concentrations can be used in a similar manner to evaluate vitamin C status. Serum ascorbic acid shows a linear relationship with the intake of vitamin C. Serum ascorbic acid concentrations below 0.20 mg/100 ml indicate low or inadequate intakes of the vitamin. Continued serum values of less than 0.10 mg/100 ml will invariably lead to signs of scurvy.

Urinary excretion levels can be used in the nutritional assessment of thiamin, riboflavin, and vitamin B-6. Clinical signs of thiamin or riboflavin deficiency may occur when urinary thiamin or riboflavin excretion, respectively, fall in the range of 20 to 30 μg/gm of creatinine. Similarly, urinary excretion of vitamin B-6 falls below 20 μg/gm of creatinine when clinical signs of a vitamin B-6 deficiency occur. More recently, sensitive and reliable functional tests, representing enzyme activity measurements, have been introduced for use in the nutritional assessment of these three vitamins. Thus, erythrocyte transketolase assays are used for thiamin, erythrocyte glutathione reductase measurements are used for riboflavin, and erythrocyte transaminase determinations are used for vitamin B-6.

When these biochemical assessment technqiues are utilized in nutrition surveys, what type of findings are obtained? With well-nourished normal persons, low or deficient values are not observed. In random populations, however, subjects with values indicating poor nutrition with respect to one or more nutrients are encountered. As an example, Figures 6 and 7 represent distribution plots for serum and erythrocyte folacin levels. Serum folacin levels below 3.0 ng/ml and erythrocyte folacin levels below 160 ng/ml are indicative of less than acceptable folacin nutriture. The figures indicate that a number of individuals with poor dietary intakes of folacin were present in the population examined.

SUMMARY

An overview has been presented as to how dietary allowances for vitamins have been established and utilized in the U.S. Military Nutritional Standards. Research on human vitamin requirements have permitted, in addition, the development of laboratory tests for the assessment of vitamin nutritional status. The procedures are reliable and practical for use in individual evaluations or in military nutrition surveys. Suitable guidelines have been developed for interpreting dietary and biochemical nutrition data. Periodic nutrition surveys can be used to determine the nutritional status of military personnel and to evaluate the nutritional adequacy of the food served and consumed. The results can be used as guidance for recommending any indicated corrective actions or adjustments in the nutritional standards of the military services.

REFERENCES

1. Hegsted, D.M. Dietary standards. New Engl. J. Med., April 24, 1975, p. 915.

2. Medical Services Nutritional Standards, Army Regulation No. 40-25.

3. Recommended Dietary Allowances. Eight Edition, 1974. National Academy of Sciences, Washington, D.C.

4. Sauberlich, H.E., J.E. Canham, E.M. Baker, N. Raica, Jr., and Y.F. Herman. Human vitamin B_6 nutriture. J. Sci. & Ind. Res. 29:1 (1970).

5. Sauberlich, H.E., J.E. Canham, E.M. Baker, N. Raica, Jr., and Y.F. Herman. Biochemical assessment of the nutritional status of vitamin B_6 in the human. Am. J. Clin. Nutr. 25:629 (1972).

6. Canham, J.E., E.M. Baker, R.S. Harding, H.E. Sauberlich and I.C. Plough. Dietary protein - Its relationship to vitamin B_6 requirements and functions. Ann. N.Y. Acad. Sci. 166:16 (1969).

7. Tillotson, J.A., H.E. Sauberlich, E.M. Baker and J.E. Canham. Use of carbon-14 labeled vitamins in human nutrition studies: Pyridoxine.

8. Baker, E.M., R.E. Hodges, J. Hood, H.E. Sauberlich, and S.C. March. Metabolism of ascorbic-1-^{14}C acid in experimental human scurvy. Am. J. Clin. Nutr. 22:549 (1969).

9. Hodges, R.E., E.M. Baker, J. Hood, H.E. Sauberlich and S.C. March. Experimental scurvey in man. Am. J. Clin. Nutr. 22:535 (1969).

10. Baker, E.M., R.E. Hodges, J. Hood, H.E. Sauberlich, S.C. March, and J.E. Canham. Metabolism of ^{14}C-and^{3}H-labeled L-ascorbic acid in human scurvy. Am. J. Clin. Nutr. 24:444 (1971).

11. Hodges, R.E., J. Hood, J.E. Canham, H.E. Sauberlich and E.M. Baker. Clinical manifestations of ascorbic acid deficiency in man. Am. J. Clin. Nutr., 24:432 (1971).

12. Ariaey-Nejad, M.R., M. Balaghi, E.M. Baker, and H.E. Sauberlich. Thiamin metabolism in man. Am. J. Clin. Nutr. 23:764 (1970).

13. Tillotson, J.A., and E.M. Baker. An enzymatic measurement of the riboflavin status in man. Am. J. Clin. Nutr. 25:425 (1972).

14. Sauberlich, H.E., J.H. Judd, G.E. Nichoalds, H.P. Broquist, and W.J. Darby. Application of the erythrocyte glutathione reductase assay in evaluating riboflavin nutritional status in a high school student population. Am. J. Clin. Nutr. 25:756 (1972).

15. Sauberlich, H.E., R.E. Hodges, D.L. Wallace, H. Kolder, J.E. Canham, J. Hood, N. Raica, Jr., and L.K. Lowry. Vitamin A metabolism and requirements in the human studied with the use of labeled retinol. Vit. and Horm. 32:251 (1974).

16. Sauberlich, H.E., R.P. Dowdy, and J.H. Skala. Laboratory Tests for the Assessment of Nutritional Status. 1974. CRC Press, Inc., 18901 Cranwood Parkway, Cleveland, Ohio 44128.

TABLE 1

RECOMMENDED DAILY DIETARY NUTRIENT ALLOWANCES
FOR U.S. MILITARY PERSONNEL*

NUTRIENT	MEN	WOMEN
Calories (Kcalories)	3,400	2,400
Protein (gm)	100	80
Fat	Less than 40% of Total Calorie Intake	
Thiamin (mg)	1.7	1.2
Riboflavin (mg)	2.0	1.7
Niacin (mg)	22	16
Vitamin C (mg)	60	60
Vitamin A (IU)	3,000	5,000
Vitamin B-6 (mg)	2.0	2.0
Folacin (mg)	0.4	0.4
Vitamin D (IU)	400	400
Vitamin B-12 (µg)	3	3
Vitamin E (IU)	15	12
Calcium (mg)	800	800
Magnesium (mg)	350	300
Phosphorus	800	800
Zinc (mg)	15	15
Iron (mg)	14	18

*For military personnel moderately active in a temperate climate; for ages 17-25 years. (AR 40-25)

TABLE 2

RECOMMENDED DAILY DIETARY OF THE
U.S. NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL*

NUTRIENT	MEN	WOMEN
Calories (Kcalories)	3,000	2,100
Protein (gm)	54	46
Calcium (mg)	800	800
Phosphorus (mg)	800	800
Magnesium (mg)	350	300
Zinc (mg)	15	15
Iron (mg)	10	18
Vitamin A (IU)	5,000	4,000
Vitamin C (mg)	45	45
Vitamin D (IU)	400	400
Vitamin E (IU)	15	12
Niacin (mg)	20	14
Vitamin B-6 (mg)	2.0	2.0
Thiamin (mg)	1.5	1.1
Riboflavin (mg)	1.8	1.4
Folacin (mg)	0.4	0.4
Vitamin B-12 (μg)	3	3

*NAS-NRC Allowances, Revised 1974; for ages 19-22 years.

TABLE 3

JAPANESE RECOMMENDED DIETARY ALLOWANCES
(1975-1980: Ministry of Health & Welfare)

NUTRIENT	MALE*	FEMALE*
Energy (Kcalories)**	2,700	2,100
Protein (gm)	80	65
Calcium (mg)	700	600
Iron	12	12
Vitamin A (IU)	2,000	1,800
Thiamin (mg)	1.1	0.8
Riboflavin (mg)	1.4	1.1
Niacin (mg)	18	14
Vitamin C (mg)	50	50
Vitamin D (IU)	100	100

*For age 18 years.

**Moderate activity.

TABLE 4

RECOMMENDED DAILY NUTRIENT INTAKES: CANADA
(Bureau of Nutritional Sciences, Health & Welfare of Canada:1974)

NUTRIENT	MALE*	WOMEN*
Energy (Kcalories)	3,200	2,100
Protein (gm)	54	43
Calcium (mg)	1,000	700
Phosphorus (mg)	1,000	700
Magnesium (mg)	300	250
Iron (mg)	14	14
Zinc (mg)	12	11
Vitamin A (μgRE)**	1,000	800
Vitamin D (μg)***	2.5	2.5
Vitamin E (mg)	10	6
Vitamin C (mg)	30	30
Thiamin (mg)	1.6	1.1
Niacin (mg)	21	14
Riboflavin (mg)	2.0	1.3
Vitamin B-6 (mg)	2.0	1.5
Folacin (mg)****	0.2	0.2
Vitamin B-12 (μg)	3	3

*For age group 16-18 years.

**1 μg retinol equivalent corresponds to a biological activity in humans equal to 1 μg retinol (3.33 IU) and 6 μg β-carotene (10 IU).

***As cholecalciferol (1 μg = 40 IU vitamin D activity)

****As "free folate."

TABLE 5

COMPOSITION OF THE LIQUID FORMULA DIET EMPLOYED IN

VITAMIN B_6 REQUIREMENT STUDIES

INGREDIENT	Consumption per subject per day	
	Low-protein diet (gm)	High-protein diet (gm)
Vitamin-free casein (micro-pulverized; 92% protein)	33	110
Fats		
Coconut oil (saturated)	84	84
Corn oil (Mazola)	36	36
DL-Methionine	2	--
Vitamin mixture (B_6-free)	10	10
Special mineral mixture	13	13
Carbohydrates (cornstarch, dextrin, glucose)	390	390
Diet provided		
Protein (gm)	30	100
Calories (kcal)	2800	2800

TABLE 6

FUNCTIONAL AND BIOCHEMICAL TESTS USEFUL FOR THE ASSESSMENT OF VITAMIN NUTRITIONAL STATUS

VITAMIN	TEST	VITAMIN	TEST
Vitamin A	1. Serum retinol levels	Folacin	1. Serum folacin levels 2. Erythrocyte folacin levels
Vitamin C	1. Serum ascorbate levels 2. Leukocyte ascorbate levels 3. Whole blood ascorbate levels	Vitamin B_{12}	1. Serum vitamin B_{12} levels 2. Schilling test
Riboflavin	1. Urinary riboflavin level 2. Erythrocyte glutathione reductase activity 3. Erythrocyte riboflavin levels	Vitamin E	1. Serum vitamin E levels 2. Erythrocyte hemolysis test
Thiamin	1. Urinary thiamin level 2. Erythrocyte transketolase activity	Niacin	1. Urinary N'-Methyl nicotinamide levels (N'-Me N) 2. Urinary 2-pyridone levels 3. Urinary 2-pyridone/N'-Me N ratio
Vitamin B_6	1. Urinary vitamin B_6 levels 2. Erythrocyte transaminase activities 3. Erythrocyte and serum vitamin B_6 levels 4. Tryptophan load test	Vitamin D	1. Serum alkaline phosphatase levels 2. Serum Ca and P levels
		Pantothenic Acid	1. Urinary excretion levels

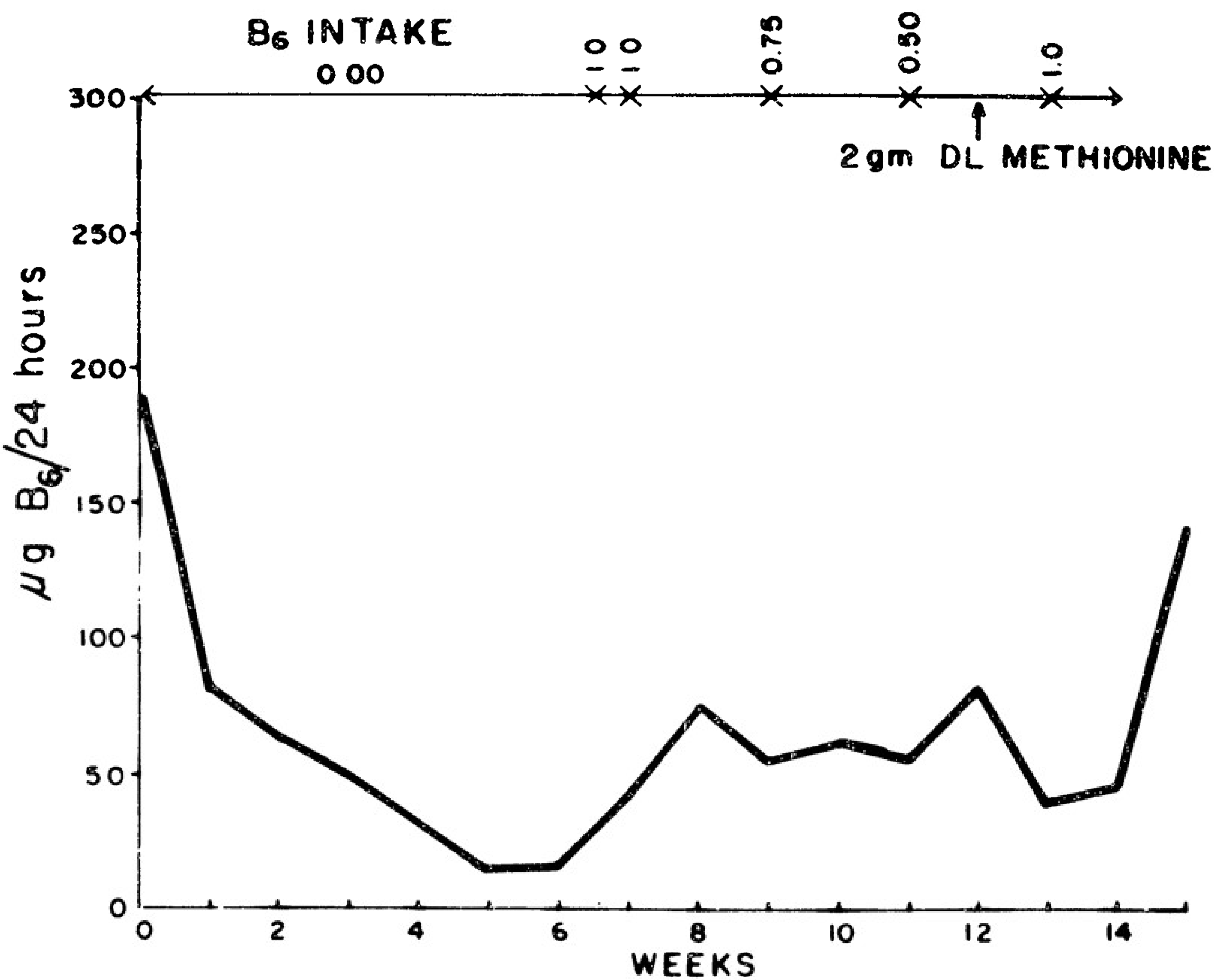

Figure 1: Effect of vitamin B-6 intake on the urinary excretion of vitamin B-6 by the adult male human (low protein diet).

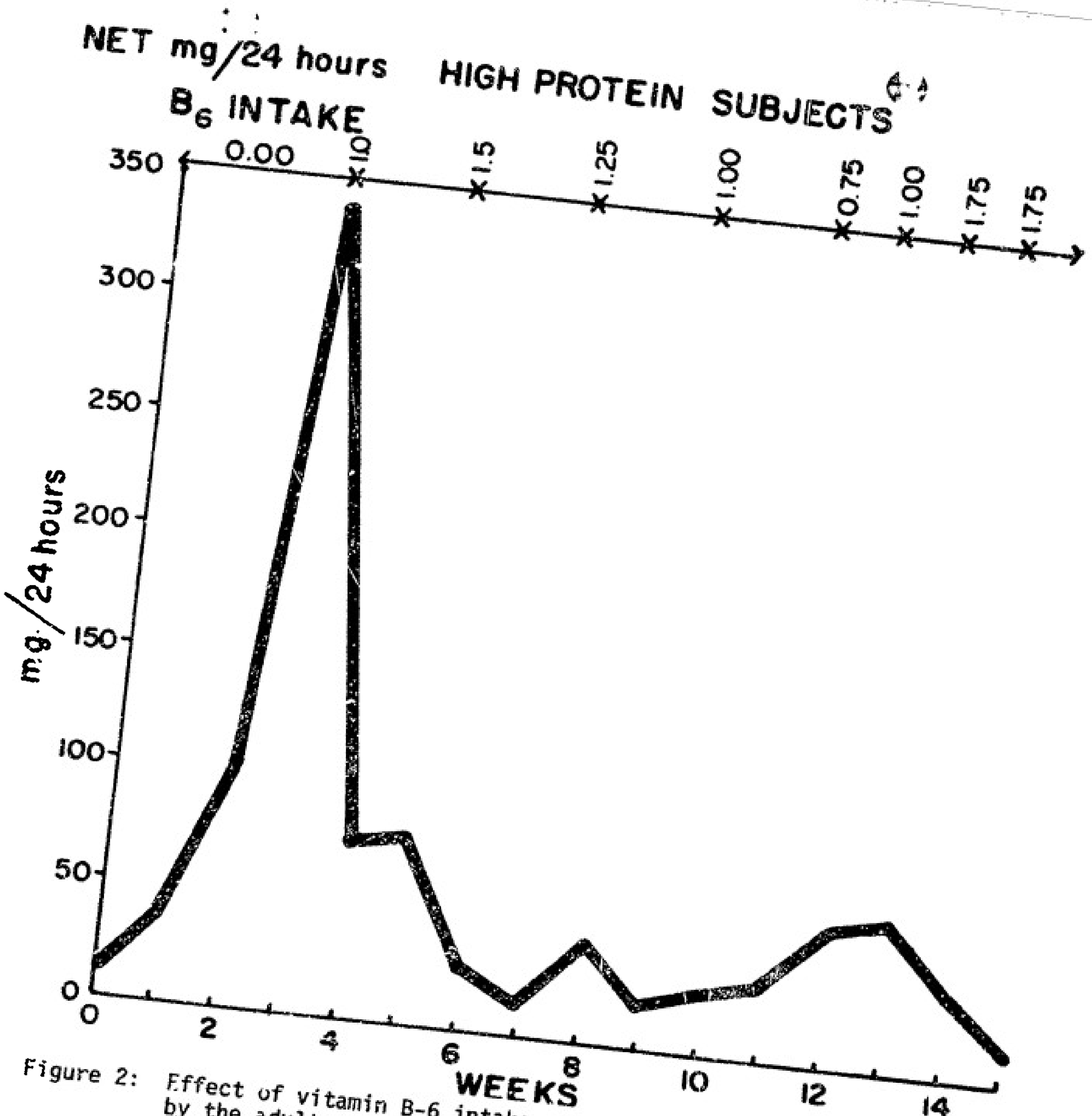

Figure 2: Effect of vitamin B-6 intake on the urinary excretion of xanthurenic acid by the adult male human following a 10 gm DL-tryptophan load.

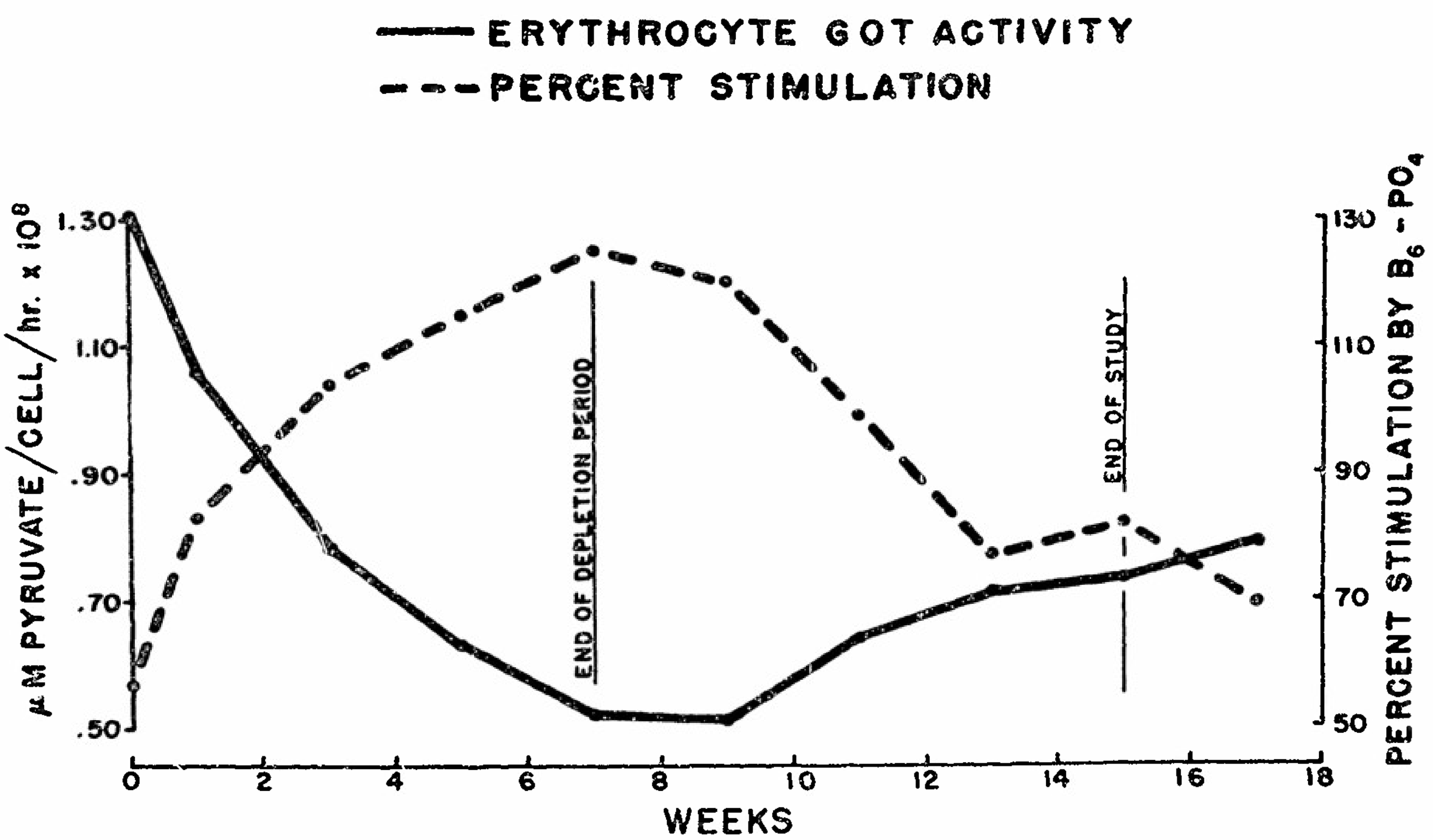

Figure 3: Glutamic oxaloacetic transaminase activity in adult male human erythrocytes and per cent *in vitro* pyridoxal phosphate stimulation during vitamin B-6 depletion and repletion (low protein diet).

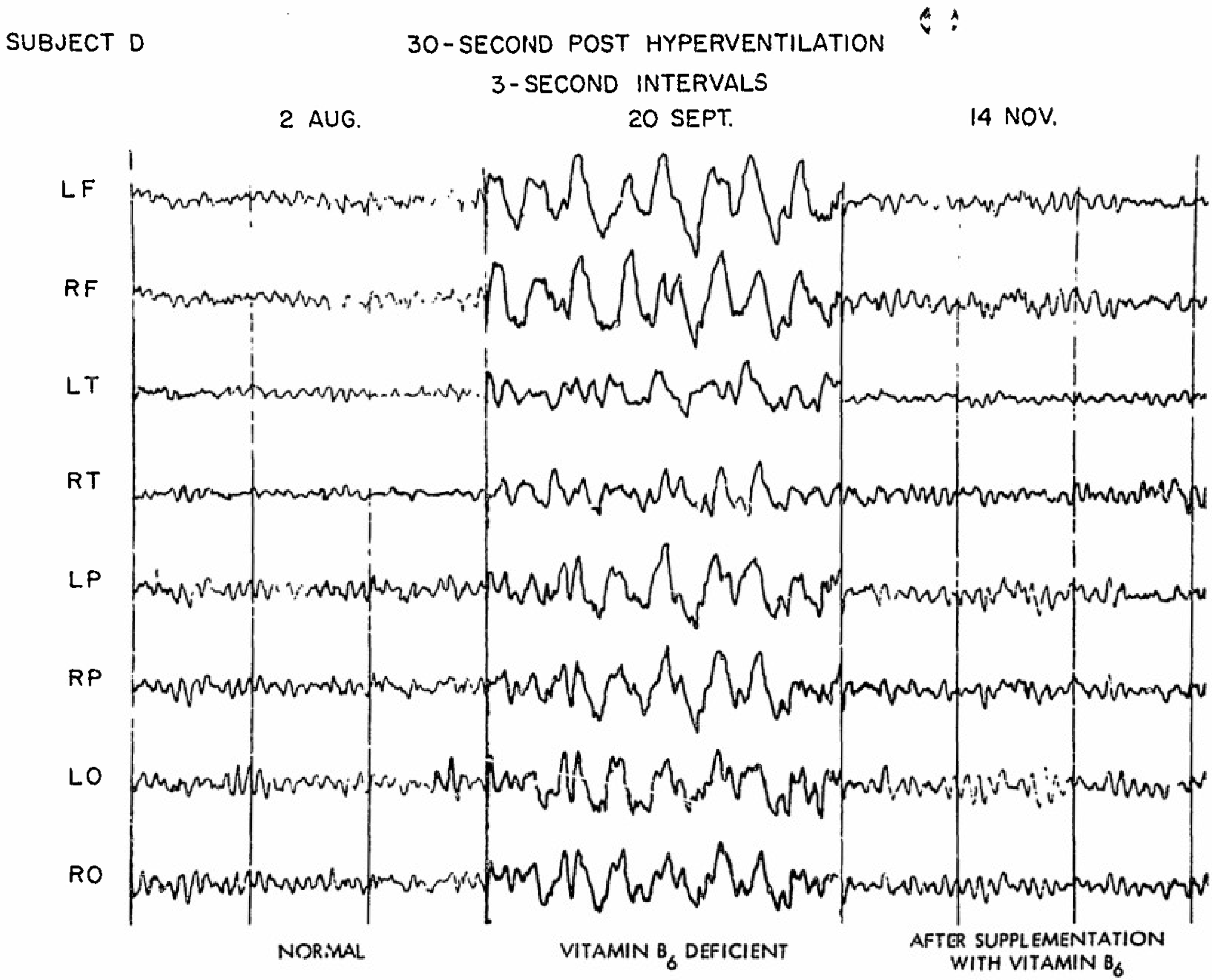

Figure 4: Electroencephalogram of an adult male human on a vitamin B-6 deficient low protein diet. (Left: prior to deficiency; Center: a peak vitamin B-6 deficiency, with abnormal slowing and increased amplitude of the waves at all leads; Right: after vitamin B-6 repletion, providing a normal pattern)

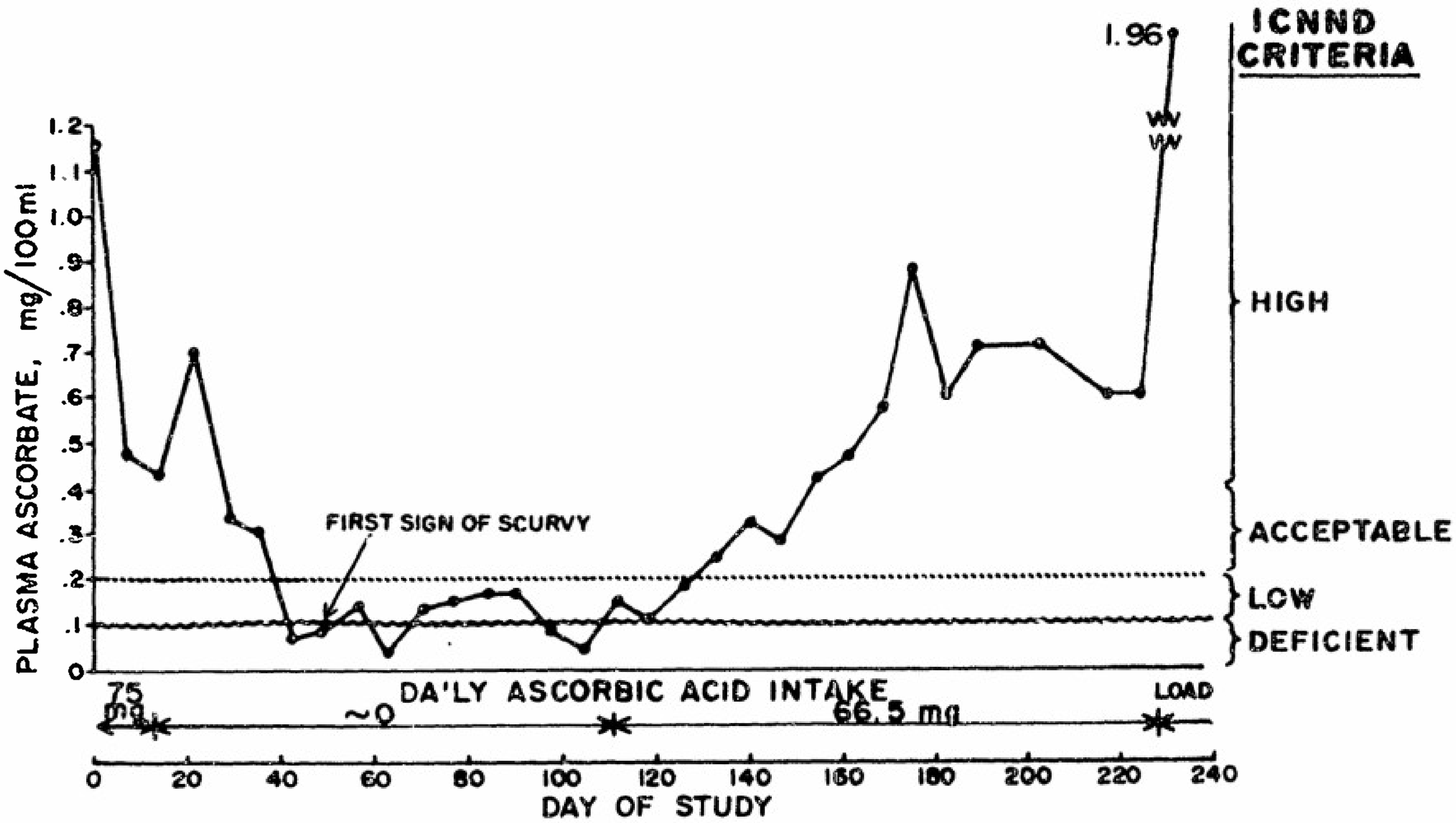

Figure 5: Effect of ascorbic acid (vitamin C) intake on the plasma ascorbic acid levels in the adult male human.

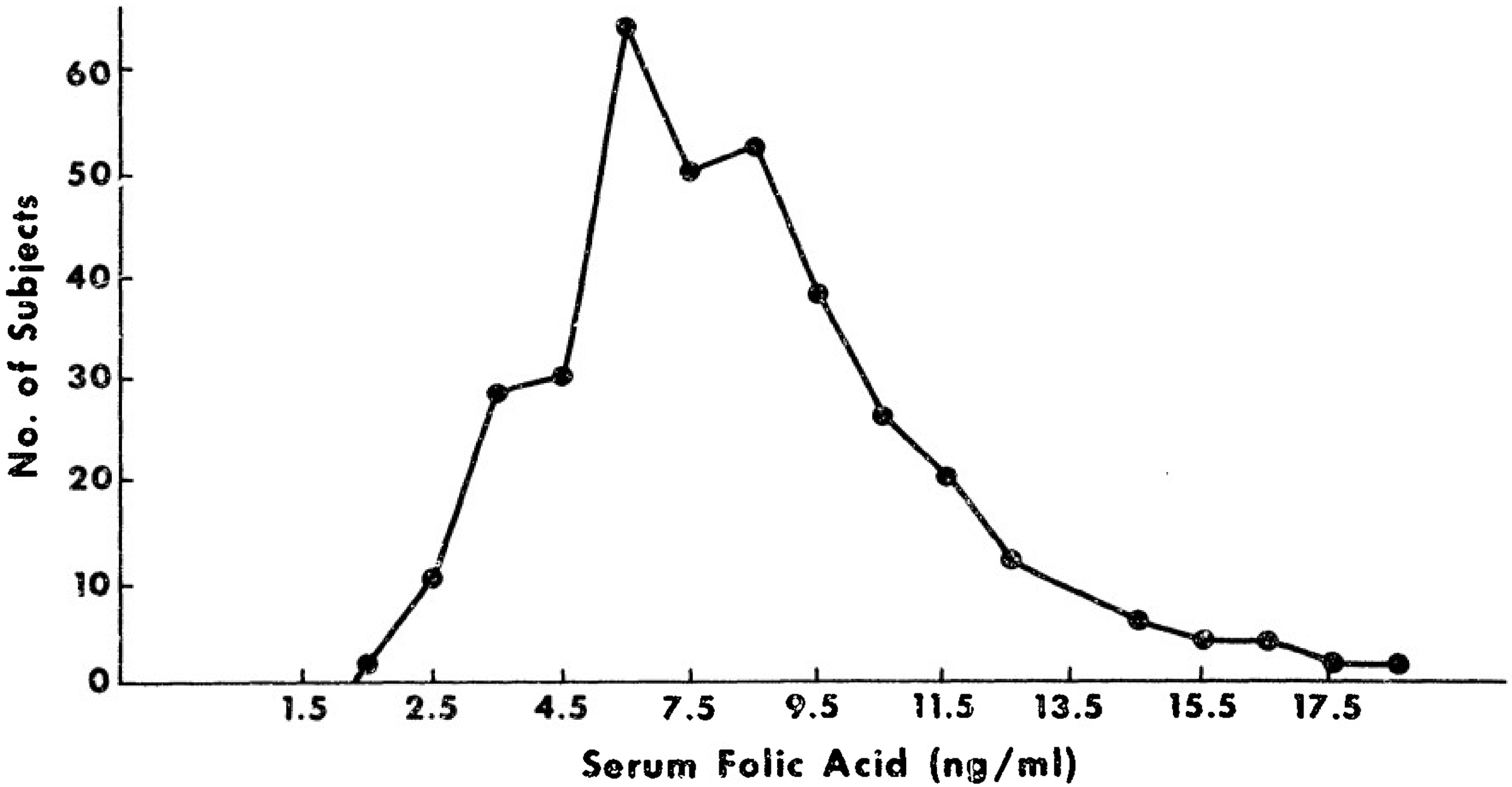

Figure 6: Distribution plot of serum folic acid values for 348 females age 18-28 years. Mean serum folic acid value was 8.2±2.8 ng/ml. Range 2.5-18.0 ng/ml. One subject had a value of less than 3.0 ng/ml, while 66 had values less than 6.0 ng/ml.

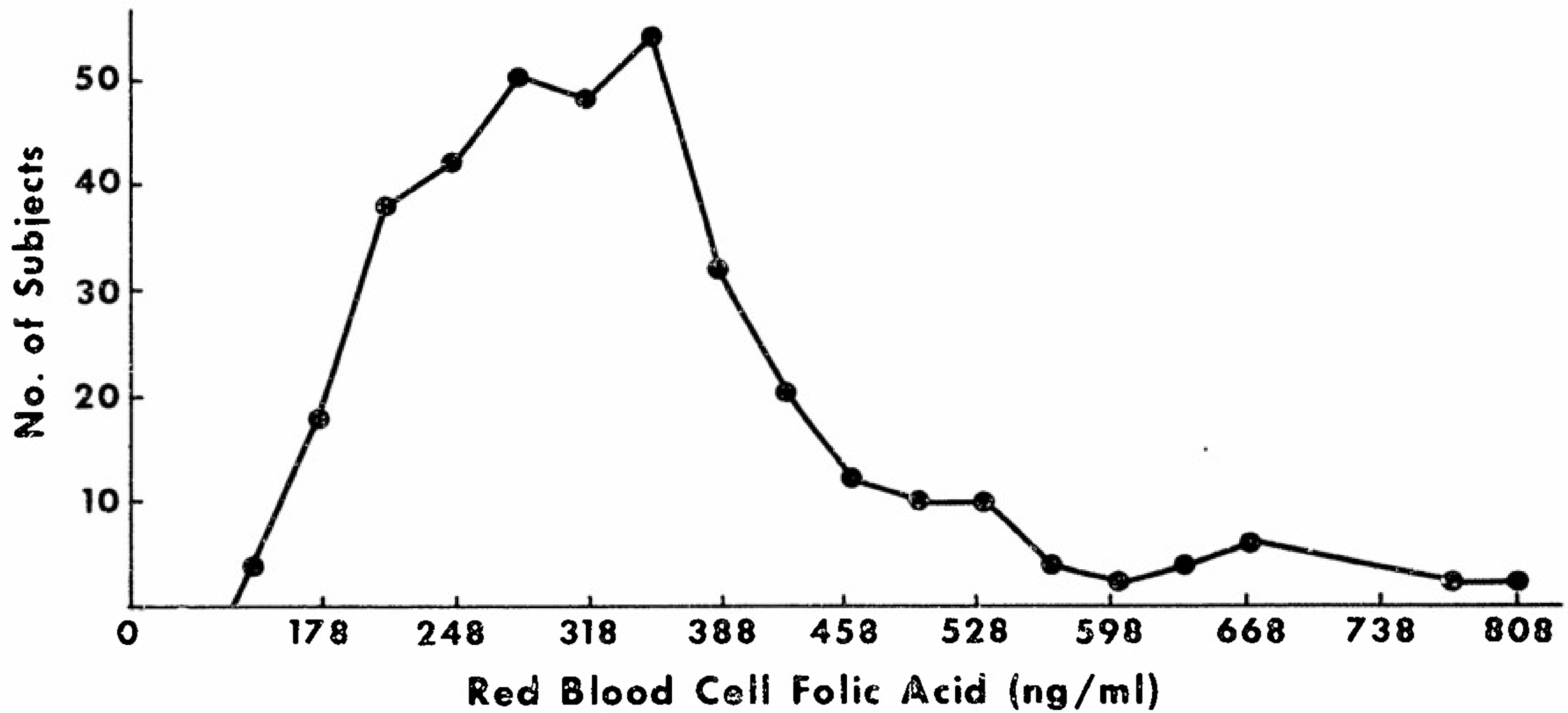

Figure 7: Distribution plot of red blood cell folic acid values for 347 females age 18-28 years. Mean red blood cell folic acid value was 330±108 ng/ml. Range 125-825 ng/ml.

THE WORLD FOOD SITUATION

By

DR. JEAN MAYER
HARVARD UNIVERSITY, BOSTON, MA

P A P E R   N O T   S U B M I T T E D

SESSION II -- OPERATIONAL RATIONS

Chairman: Dr. Dale H. Sieling
Technical Director
US Army Natick Research & Development Command
Natick, MA

Developments in the Canadian Individual Ration Pack	Major Jean Wallace Canada
Storing, Turnover & Control of Special Rations in Mobilization Stores	Lt. Col. Bertil Ackerot Sweden
Research & Development of Operational Rations	Col. W. H. Blakemore U.K.
Logistical & Technological Aspects of NL Operational Rations	Lt. Col. V. Dumas and ing. J. F. Spieksma The Netherlands
Danish System of Operational Rations	Lt. Col. Ejvin Larsen Denmark
Meal, Ready-To-Eat, Individual--Latest U.S. Operational Ration	Dr. Herbert A. Hollender U.S.A.
More Uniformity of Special Rations	Col. O. M. Jorgensen Norway
Flexible vs. Rigid Packaging for Operational Rations	Dr. Rauno A. Lampi U.S.A.

Guest Speaker: Dr. Marcus Karel
Professor of Food Engineering & Deputy Head
Dept. of Nutrition & Food Science
Massachusetts Institute of Technology
Cambridge, MA

Subject: Engineered Foods in the Food Supplies of Tomorrow

DEVELOPMENTS IN THE CANADIAN INDIVIDUAL RATION PACK

N. A. Galbraith
Department of National Defence

INTRODUCTION

1. Canada's requirements for the Individual Ration Pack, or IRP in familiar terminology, have varied from 200,000 to 600,000 packs per year. As component quantities are too small to justify special manufacture, the seven menus of the pack are based, with few exceptions, on canned and packaged food items that are widely available on the Canadian market. This policy supports our food industry and provides the military consumer with familiar foods bearing well accepted brand labels. The decidedly non-commercial three-year shelf life requirement for the pack is met by judicious selection of the menu items, stringent quality inspection including special incubation tests on the canned meat and poultry items, and additional protective overwrap of components such as biscuits and candy during assembly of the IRPs in the military packaging depot.

DESCRIPTION OF EXISTING IRP

2. The existing IRP design, first produced in 1972, is a two-compartment pack with the canned items in one box, and the three pouches containing the biscuits, and all the miscellaneous beverage, confection and dessert items in an identical second compartment. Each pack contains a card of six fuel tablets and a windscreen, used in conjunction with the soldier's canteen cup to heat water and the canned entrees, as well as containing a can opener, spoon, matches, tissue, etc. The dimensions, and the average weight and caloric value of the seven menus in this design are:

	Calories	Length	Width	Height	Weight
Single IRP	3800	8½"	5½"	6"	5lb 2oz
Case of Five IRPs	19000	29½"	8½"	7"	28lbs

REDESIGN APPROVED FOR 1976 PACK

3. The quality and variety of the Canadian IRP menus generally rate very favourably with the consumer and in comparison with the ration packs of other nations. Therefore, redesign effort has been focused on reducing the weight and cube of the pack and the amount of packaging material to be discarded following consumption. Significant savings in these areas will be achieved in the 1976 pack by redesigning the packaging, deleting the fuel tablets and heat shield from the pack, and reducing the size of the biscuit pack. It was a user decision to remove the fuel from the pack for separate issue when and as required.

4. The redesigned IRP will continue as a two-compartment pack but with lightweight folding cardboard trays, overwrapped in low density polyethylene

shrink film, replacing the two stout "E" flute corrugated fibreboard boxes of the 1972-1975 packs. The tight wrap of the shrink film eliminates the necessity for separators between the cans and the transparent property of the film eliminates the necessity for identifying the compartments in the packaging line. As with its predecessor, the two compartments will be strapped together by a bundling machine before placement of five each packs per shipping case.

5. A 42% saving in packaging material costs and reduced packaging man hours are forecasted, in addition to savings of 12% in cube and an average of eight ounces in weight per pack. It has been calculated that the decrease in packaging material costs and pack assembly man hours will soon offset the cost of the high-speed sleeve wrapper and tunnel machine required to shrink wrap the two sections of each pack. The revised design readily passed rough handling tests in a revolving drum with twenty-four varied and brutal impacts inflicted on each of the seven cases (of five like menus per case) in the series.

6. The dimensions and average weight and caloric value of the seven menus of this redesign are:

	Calories	Length	Width	Height	Weight
Single IRP	3700	7 1/8"	5 3/8"	6¼"	4.5lbs
Case of Five IRPs	18500	28½"	7 3/4"	6¼"	22.5lbs

7. Food component changes incorporated in this redesign are intended, primarily, to maintain interest in the menus but also recognize newly available items, i.e.

a. in addition to the familiar Swiss Oatmeal Cereal, there are two other instant porridges - a blueberry apple oat cereal and a crunchier cereal. In foil laminate pouches, they require only the addition of a small amount of hot water to the pouch to provide hot cereal. Milk and sugar are part of the formula(e);

b. instead of the one ounce tube of Australian tropical butter compound, there will be a one ounce pouch of an edible vegetable oil spread, developed for the ration pack by a food firm in Toronto, Canada. Purchasing lead time on the Australian butter has made supply in time for the packaging program most precarious at times;

c. the plain biscuit pack has been reduced from five and one-third ounces, frequently reported as too generous, to four ounces. The smaller biscuit pack is responsible for the cube saving in the miscellaneous half section of the pack;

d. several new sweet biscuits have been included; raisins, unavailable for two years, will return with the 1976 pack; and, for the first time in ten years, there will be no green-coloured candy-coated chocolate discs to be saved until the soldier returns home again and tossed out into the grass to keep the kids busy;

e. changes in the canned components include introduction of stuffed cabbage rolls in a tomato sauce, macaroni with ground beef in a tomato-cheese sauce, dumplings with chicken in gravy, beef steak with mushrooms and gravy, and the return of corned beef after a several-year absence. The cans of pre-fried bacon and smoked ham remain special, and relatively very expensive, menu items in the series;

f. there are now seven flavours of cream desserts, with the addition of lemon, coconut, and strawberry puddings;

g. the soup mixes are also in seven varieties, with the introduction of a thick mushroom soup;

h. the beverage powder mix has been increased from a six to eight fluid ounce yield, with a small increase in Calories and Vitamin C;

j. two tea bags, overwrapped in a foil laminate pouch, are replacing the packet of instant tea, which has proven so unpopular.

CONTINUING SHORTCOMINGS OF PACK

8. Despite the reductions in cube, weight and packaging material discard, the new design for 1976 production is still bulky and heavy for an individual ration pack. Also, although the quality of the food components is excellent when judged as canned products, they will never compete in acceptability with the freshly prepared equivalents.

DIRECTION OF FURTHER REDESIGN EFFORT

9. Advances in reversible decompression of dehydrated and freeze dehydrated foods could eventually effect significant reductions in weight and cube of the pack but the products are unlikely to prove more palatable, and may never become a viable commercial alternative to the canned products. Little work has been done in the field of compressed dehydrated food in Canada because of its limited commercial application, but a Norwegian firm is considering establishing a plant for this purpose in the province of Manitoba.

10. The flexible retortable pouch, presently a commercial alternative to the can in a number of countries and a successful if very expensive reality in the United States military system, is superior to the canned product in flavour and texture but appears to offer only a small reduction in cube and little or no weight advantage. The flexible pouch (and cardboard over-sleeve) is of course readily compressible for disposal. In general, North American food processors have shown little interest to date in producing thermo processable, flexible pack entrees because of the high initial expense. There is now one Canadian firm with a five-product line, including chicken stew, ravioli and small whole potatoes. It is intended to undertake physical testing of the pouches and organoleptic assessment of the contents shortly.

Other Canadian food processors are being encouraged to investigate the commercial viability of the concept.

11. Pending further technological advancements and commercial development in compressed dehydrated and retortable flexible pack foods, Canadian redesign effort on the individual pack will continue to focus on organization of the components and packaging. Although still in draft form, the new official "Statement of Requirement" for the time frame 1975-1985 substitutes a meal pack concept for the twenty-four hour ration pack concept. It demands sufficient flexibility of design in the pack that it could replace the present Lightweight Patrol Meal Pack as well as the IRP. It is, of course, intended that a combination of three of the envisaged meal packs will supply the calories, nutrients and component variety of the present IRP while reducing cube, weight and packaging material discard.

12. The following advantages have been claimed for the meal pack concept over the ration pack concept:

a. Simplicity of Use. No selection of meal ingredients is necessary by the consumer. Despite the menu pattern in the IRP, the consumer often fails to organize the collection of components into satisfactory meals;

b. Adaptability to Feeding Requirements. Issues can be made in direct response to the number of meals to be eaten. The twenty-four hour IRP is not satisfactory from a control, issue, consumption, or economic standpoint when other than three meals or multiples of three meals have to be issued. It cannot be divided equitably amongst three persons either from the content or packaging aspects;

c. Stowage by Individual. Where logistic support can cope with issue of one meal at a time, the individual would not have to carry a full day's supply as is the case with the IRP. However, when the full day's ration is issued at one time, the three smaller meal packs could be stowed more readily about the soldier's person than one IRP (or the two sections of the IRP);

d. Balanced Nutritional Value. With a meal pack, a nutritionally balanced, approximately 1250 Calorie menu would be available for each meal.

Also, assuming that technological advances in the food industry permit, the meal pack series could, as demanded by the "Statement of Requirement", replace both the Lightweight Patrol and standard Individual Ration packs, with obvious logistical advantages.

13. Those opposing the meal pack concept argue that:

a. accessory items must be repeated per meal instead of per day, e.g. matches, spoon, sanitary tissue;

b. breakfast menus should be distinct from lunch/supper menus, and therefore control and issue must recognize this difference as well as menu variety demands;

c. more effective supply management would be required in rotating stock and issuing menu variety with twenty-one meal packs as opposed to seven ration packs;

d. the amount of packaging material would likely increase with three meal packs instead of one ration pack, and the protective foil laminate overwrap of biscuits and confections would have to be applied to several items rather than the present full day's requirement in the form of an accessory bag.

CONCLUSIONS

14. It is believed that the advantages override the disadvantages and that a meal pack concept may best meet Canadian Forces requirements in the future. However, important advances in food technology must be forthcoming and implemented by industry before a new, lighter and more compact design is achieved while still basing the pack on foods commercially available on the Canadian market.

Lt Col Bertil Ackerot
Sweden

Oct 1975

Storing, turnover and control of special rations in mobilization stores

1. General

In order to guarantee that the units are provided with necessary provisions, i e (that is) immediate supply of a certain quantity of provisions at mobilization, so-called special rations are stored in the units´ mobilization storehouses.

Such a storing of rations takes place for all units. The quantity of rations to be stored for the different units does, however, vary, depending, inter alia, on the organization and the task of the units and on which possibilities there are to provide the units with provisions on normal supply roads.

The intention of storing special rations in mobilization storchouses consequently is, that during mobilization, the units shall have direct supplies of provisions for a certain number of days and nights. If this supply can take place in the normal way - for instance, in such a way that provisions are supplied to the units by a civil supplier or from a military storehouse - the special rations shall of course not be consumed. For several reasons, it is important that the special rations shall be saved as long time as possible. Among other things, these rations are comparatively expensive and as they have a good durability, it is certainly easy to keep them at the units or to continue storing them in the storehouses.

2. Examples of different kinds of special rations, stored in mobilization storehouses

Ration of food in mobilization stores.

In the first place, these provisions are intended to be used if ordinary supplies of provisions to the unit do not function during mobilization. Examples of these articles:

Meat dish (complete dish, canned)
Sweet soup (dried fruit-soup)
Biscuits
Cocoa powder
Coffee
Lump sugar
Chocolate bar

Emergency (survival) rations

An emergency ration intended for one person during 24 hours to be used instead of ordinary rations when they cannot be supplied. Examples of such articles:

Meat dish (complete dish, canned)
Sweet soup (dried fruit-soup)
Biscuits
Liver sausage (canned)
Coffee
Sugar
Salt
Chocolate bar

Ration of food for rangers (commando soldiers)

Provisions for a commando soldier during 24 hours, to be used during tasks, when ordinary portions cannot be supplied. Examples of such articles:

Meat or fish dish (complete dish, freeze-dried)
For the rest, on the whole, according to the emergency rations.

Survival rations

Survival rations are stowed in submarines, lifeboats, life rafts and airplanes. Their contents mainly consist of compressed, dried fruit, chocolate bars, tea, sugar and salt.

Canned meat and pork

These types of canned foods may, inter alia, bs part of the units' prescribed equipment.

3. Storing

The intention is to store the special rations in the mobilization stores for a period of four years.

The types of storehouses in which the provisions are stored, are of a very varying quality.

Examples: wooden building of a simple design, sheet-metal storehouse without special insulation and insulated wooden storehouse or stonehouse with or without heating arrangement.

This means that temperature and air humidity may vary considerably. In the directions for construction of storing spaces, there are no particular requirements of temperature, relative air humidity etc. On the other hand, it is recommended that foodstuffs should be kept in such a place in the storehouse, where the changes in temperature and humidity are considered to be least. If possible the temperature should not exceed +20°C (+68°F).

Consequently, the provisions will be exposed to very great stresses during the storing, for instance, through the fact that in winter the temperature may be -10° to -35°C (+14° to -31°F) and in summer +15° to +35°C (+59° to + 95°F).

It is, of course, to be desired that the provisions should be stored under better conditions than those mentioned above. Demands for better storehouses, should however, mean considerably increased costs and perhaps difficulties to store foodstuffs together with other equipment of the units. In order to keep a high mobilization preparedness, the equipment of a unit should, if possible, be collected in one place in a few storehouses.

The care of the provisions during the storing time in the mobilization storehouses is not very comprehensive. It consists first of all, of inspections that the ration cans and boxes have not been damaged from damp, noxious animals or other external influence. It is also controlled that the tin cans have not been damaged, or that they are tight.

The personnel performing the control is "ordinary storehouse personnel" with a certain training in how foodstuffs should be stored and handled. Particularly, they have learnt, what should be controlled in the first place by provisions, stored in this way.

4. Turnover

When the provisions have been stored in four years, the intention is that they should be renewed. This turnover shall take place during the fifth year, at the latest.

In the first place, this turnover shall be realized in that way that each war unit consumes its own special rations in connection with exercises. The leading principle is that the units shall have refresher training during some weeks every fourth year.

However, certain units are exempted from this four years cycle, for different reasons. In certain cases, it has perhaps been necessary to cancel the training for financial reasons. Consequently, there will be rations which have to be renewed in another way.

The turnover may then take place at the units effecting their basic training. In the first place, the rations should then be prepared by the kitchen personnel of the units in connection with training in companies and battalions.

To a certain extent, we are also forced to consume special rations in the dining rooms of the units. This is an emergency measure and as far as possible, we try to avoid it.

A certain assistance with the turnover will perhaps be possible by means of an agreement between the defence authorities and SIDA (Swedish International Development Authority). In such a case, SIDA should renew the provisions in connection with their help to countries suffering a disaster or countries suffering from an acute famine. Certain negotiations have been opened between the defence authorities and SIDA.

To facilitate the turnover of special rations, FMV (the Defence Materiel Administration, Sweden) gives, inter alia, advice and instructions, how to prepare foodstuffs in the best way and otherwise about what can be done to make the food stuffs as appetizing as possible. There certainly is a certain opposition from the soldiers againsthaving to eat canned food and dried foodstuffs. For that reason, all kinds of measures have to be taken to make the special rations as appetizing as possible.

5. Control of special rations by FMV

The important condition to get special rations of good quality and taste, is, of course, that raw products of the best quality and good cooking receipes are used, and that the preparation of the food takes places with the greatest care and accuracy.

FMV provides the manufacturers with detailed preparation instructions. The preparation is controlled by FMV's own inspectors.

On the whole, the control after preparation is of the following extent:

Heating chamber test:

1 - 2% of the prepared quantity are tested. Storing of foodstuff samples for 8 days in +37°C (98.6°F). Thereafter storing of the samples for 8 days in +20°C to +25°C (+68° to +77°F).
Continous control of the foodstuffs during the testing period.

Storing tests

A certain small quantity of each prepared lot and kind of foodstuffs is stored in comparatively unfavourable conditions, i e (that is) in a uninsulated storehouse in that part of Sweden where temperature differences are great during the year. The rations are stored there for four years. Every year samples are tested by FMV.

Guarantee storing

This is a storing of canned food during the period for which the supplier guarantees the quality of the goods. The quantity to be tested constitutes 1% of each lot (prepared) of the canned food. The storing takes place in definite temperature and air humidity conditions. Temperature +5° to max +20°C (+41° to max 68°F). Relative air humidity max 80%.

If FMV discovers faults in the sample lot, this may give rise to claims of the supplied lot.

A control of the special rations may also take place through random tests of provisions stored in different mobilization storehouses or in connection with renewal of the provisions. These tests are carried out by FMV.

A certain following-up of the quality of the provisions is also obtained through the reports delivered by the units during the storing time and at the renewal of the provisions, when damages or suspected damages have arisen on the goods.

6. Experiences

On the whole, storing of special rations in mobilization storehouses in the way described above, has functioned well.

The number of damages on provisions in storehouses has been very small. Only on one occasion has it been necessary to reject a lot of canned food, since 1970.

The quality deterioration during the storing period is also judged to be comparatively small

For that reason, the result of storing special rations in mobilization stores can be said to be good.

RESEARCH AND DEVELOPMENT OF OPERATIONAL RATIONS

By

Colonel W H Blakemore
United Kingdom

INTRODUCTION

The overall responsibility for the provision, storage and distribution of food consumed by the Services is vested in the Director General Supplies and Transport (Navy and through him to the Director Supplies and Transport (General and Victualling) - DST(GV). One of the responsibilities of DST(GV) is to carry out research and development of Operational Rations.

Of the 3 UK Services the Army is by far the major user of Operational Rations and it is therefore natural that they should provide the guidelines for the development and production of such rations. The Army Logistic Development Committee in policy papers sets out the direction which research should follow. The current policy covering the period up to 1980 emphasises the need to reduce weight, to speed up the time in preparation of foods, and to make greater use of dehydrated foods.

PARAMETERS

Operational ration packs whether for communal or individual feeding are required to provide sufficient energy necessary to allow the soldier to function with optimal efficiency and to provide those dietary adjuncts which are not normally stored by the body for extended periods of time. Therefore the need is to provide a balanced range of items, which are relatively easy to transport without damage, easy to sub-divide if necessary, easy to prepare, and which provide meals which are as varied and attractive to eat as is possible in the circumstances of their preparation. However there are other factors which have to be considered which have a major bearing on the contents of any pack. There is the need for items to be stable under conditions of storage and for periods of time normally not encountered by commercial products.

The shape and contents of any operational ration pack reflects the nature of the constraints which are placed on the design and are a compromise of a number of conflicting requirements. Factors which have a bearing on the design include firstly, the purpose of the ration, the conditions under which it is envisaged that they be used, the standards of acceptance likely to be tolerated under conditions of use; secondly the weight, volume and standard of packaging relative to the storage capabilities and ultimate distribution and use. Thirdly the reconciliation of the cost to produce, to store, and the penalties which accrue from the need to turn over and replenish the rations at the end of their life. In this connection the argument that instincts of survival make acceptance of foodstuffs a formality is not sustained where such foodstuffs have, at least as a matter of financial expediency, ultimately to be eaten rather than being written off. Finally it is the intention that most items included in operational rations can be eaten either hot or cold.

CURRENT RANGE OF OPERATIONAL RATIONS

The range of operational ration packs currently in production are

(a) 10 and 4-man Composite Ration. Both packs are designed for use for periods up to 30 days in conditions where some degree of communal feeding is possible. Both packs are produced in 7 menus and the packs weigh 40 lbs and 19 lbs respectively. The rations comprise mainly canned items, although over the past three years both tea and instant coffee have been packed in sachets instead of cans. The calorific value of each ration per man is 2,800 and 3,300 K cals respectively but these are brought up to 4,000 K cals with the appropriate quantity of Service biscuit which is issued separately.

The normal shelf life of both rations in temperate climate is 3 years. This can be extended to 5 years by storage in cool conditions at a temperature of ~~plus or minus~~ 2°C (35°F) and at 60% RH.

(b) 24 Hour Ration GS. This is an individual ration, produced in 4 menus. As is the case with all individual rations this ration provides a breakfast meal, a snack meal and a substantial main meal. Beverages are provided to supplement each meal.

The main components of the breakfast and main meal are canned.

The calorific value of the ration is 4,000 K cals. Each ration weighs 4 lbs and is packed in an individual skillet, 10 of which are packed in an outer case.

The ration has a shelf life of 2 years in temperate climate.

This is a popular ration with servicemen as it allows each man to suit his own needs in the preparation of his food.

(c) Special Air Service Ration. This individual ration is produced in 3 menus. Unlike other rations each menu contains canned fish and twice the normal quantity of dehydrated meat granules. It needs 5½ pints of water. This ration meets the special requirement of the SAS and cannot be compared with other individual rations.

The ration weighs 2½ lbs and produces 3,700 K cals. It has a shelf life of 18 months in temperate climates.

(d) Royal Marine Arctic Ration. This is an individual ration used for the Royal Marines and for which the Army has no responsibility. It is likely however that it will in future be issued to meet the Army's small requirement for an individual Arctic Ration. The ration is produced in 4 menus. It is a lightweight ration weighing 3 lbs and producing 4,500 K cals.

The ration has a high content of dry and dehydrated items and 6½ pints of water are needed to reconstitute the ration.

It has a shelf life of 18 months in temperate climates.

This ration has proved to be very popular with Service Expeditions and has been used continuously for periods up to 30 days.

CONTINUING DEVELOPMENTS

It is now 5 years since the last major changes were made to the 10 and 4-men Composite Rations. At that time both packs had 8 menus of which 2 were reserved for "tropical" use. When the menus were revised both tropical menus were dispensed with and the opportunity taken to introduce new items.

Experience had shown that certain items were unpopular and complaints ranged from the general monotony and lack of variety, particularly in the breakfast meal, to inadequate bulk of the ration. Such complaints highlighted the problems inherent in the use of rations designed for use under combat conditions rather than in peacetime exercise conditions.

Breakfast meals continue to be the most difficult to provision with adequate variety. All the current menus contain beans in tomato sauce as a component of the breakfest, the other being a choice of canned sausagea, bacon grill and bacon burgers. Thees replaced canned sausagea plus beana in tomato sauce in 4 menus and sausage and beana (in the same can) in the remainder.

Improvements have also been mads in main meals and notice taken of the trend in feeding habits particularly the increase in popularity of rice and curry. Traditional items such as Irish Stew and Meat and Vegetables have been replaced by Goulash and Chicken Curry. Rice has been substituted for mashed potato powdor in menus in which chicken figures as the main dish.

To meet the requirement of the ALDC policy paper to reduce the weight of composite rations triale have been carried out with items such as tea, sugar, rice, potato mash powder, packed in sachets instead of cans. To date only tea and instant coffee sachets have been adopted.

The 10 and 4-man packs owe a considerable portion of their rigidity and load-bearing capability to the maximum use of cans within the pack. The trial showed that any further substitution of cans by sachets beyond tea and coffee in the sachets caused storage problems. The rations are normally packed in the case of 10-men packs 60 packs to a pallet in a 3 x 4 x 5 configuration. For space economy stacks are normally 3 pallets high. In the trial the pallet straps on the bottom pallet were found to be clear of the packs by 4 inches and the case sleeves on each pack were found to bulge by more than one inch. Considerable damage to the cans also occurred within individual packs, the amount depending on the position of the case in the pallet. A further trial is due to start shortly but it may be that the incorporation of further sachets in the packets cannot be achieved with the pack in its present form and that a completely new configuration will be necessary.

One major problem that has affected the storage life of Composite Rations, is the effect that tomato-based products have had on cans made from electrolytic plate and internally lacquered. The lacquers were first introduced to reduce sulphide staining but the range of use was extended. Recent studies have shown that the use of lacquers has not been trouble free and there is evidence of scratching and pin-holing together with permeability to oxygen and ions in solution. These defects have been shown to affect the electro-chemical systems in the can.

In general, with acid foods in plain tin cans, the tin content rises with time and temperature. The tin acting as a sacrificial anode results in a low dissolution of lead from the seaming solder whilst in lacquered cans, the tin content will remain low but the localised electro-chemical effects produced by lacquering faults may result in enhanced lead and iron contents. The enhanced lead content may be associated generally with the incidence of solder splashes at can seams. Pending a solution being found to the problem, tomato-based products are being packed in cans made from hot dip plate.

It has also been found that off flavours have developed in pre-cooked rice when packed in a can after 2 years storage. This does not occur to the same extent when the rice is packed in a laminate. Tests have shown that volatile aldehydes build-up at different rates according to the method of packing. There are indications that a valuable predictive information may be gained within a 6-month period by headspace gas analysis and work on this aspect is continuing. Improvements have been made in individual rations with the introduction of the packing of Biscuits Service and Oatmeal Blocks in flow-line triple laminate. This has replaced the more cumberaome Kraft paper and foil pack which were hand-packed and were subject to many failures. A new fruit-filled biscuit is now being packed in the 24-hour ration and RM Arctic ration and replaces one 3 oz packet of normal Service Biscuits. Investigation had shown that rarely were all the 9 ozs of Service Biscuits contained in these packs eaten and the new biscuits were introduced to encourage the soldier to consume the entire ration. In order to ensure that the packs are adequate as a sole source of food riboflavin and thiamin has been added to the biscuits and vitamin C to the boiled sweets.

A prototype Lightweight Ration weighing 1 lb gross and producing 1,800 K cals has been developed to meet the ALDC requirement for a soldier on patrol to carry his rations with him for up to 10 days without replenishment. The prototype ration produced 1,918 calories 37½% of which came from the fat content. The ration was produced from standard items already included in other operational rations. Troop trials carried out with earlier prototypes have indicated that 10-12 days is the maximum period that a soldier is able to carry out arduous duties on such rations before there was appreciable loss of efficiency. After this time a period of recuperative feeding must take place. While investigation still proceeds there is difficulty in producing more than one menu and still maintaining the ratio of protein and fat required. Even if this proves possible it is unlikely that such a ration would be popular in peacetime and as referred to previously this produces problems with the turnover of stocks. It is improbable therefore that the ration will be produced in the near future and it is likely that the final specification will remain on file.

FUTURE DEVELOPMENTS

It would seem that the 10 and 4-men packs have reached the limit of their development in their present form and there will have to be the introduction of new style packaging before there can be a radical reappraisal of either pack.

We do of course have hopes of the sterilizable flexible pouch although development of this particular pack has been slow in the UK. The introduction of an expensive gourmet range in a national chain store has not taken off as hoped but this may be due to the present economic climate in Britain. Although co-operation between industry and DST(GV) is extensive few products prepared to a Service specification have been received presumably because of the industry's own requirements to test market. Both the cost and the problems likely to be encountered in their packing for Service use make it probable that such packs cannot be incorporated in Service operational rations in the near future.

In the immediate future therefore the future development is likely to be limited to the improvement of the quality of existing items and the introduction of easy to prepare commercial convenience foods such as instant soups. Up to the present the introduction of textured vegetable protein has not been acceptable to the Service Food Directors although in view of their value as meat extenders their introduction may not be long delayed.

No major change is envisaged in the format of any of the current operational ration packs in the immediate future. However there is a case for a larger module (say 25 men) for communal feeding in the field and we are prepared if an operational requirement was stated for such a pack.

LOGISTICAL AND TECHNOLOGICAL ASPECTS OF NL OPERATIONAL RATIONS

by Lt. Col. V. Dumas and ing. J.F. Spieksma
Quartermaster-General, Netherlands Army

INTRODUCTION

From the point of view of our present functions and tasks within the Quartermaster-General's organization Mr Spieksma and I are responsible for the class I supply of the Armed Forces. I am Lt. Col. V. Dumas, Deputy Chief of Material-Branch nr 7 which includes among other things, procurement, technology and supply of class I and Mr Spieksma is chief of the Bureau of technology class I.
Regarding food Material-Branch nr 7 is acting on behalf of the Quartermaster-General as 'Single Service Manager' for the three Armed Forces.
We are delighted to be here and very pleased to participate in this important multi-nation conference on food.
Our subject deals with operational rations and therefore the accent will be put on food-supply in time of war and its characteristics;
Mr. Spieksma will explain the technical aspects, whereas I am going to give a brief review of the logistical aspects.
The following will give you an insight in the way conforming to which base-principles these tasks are being realized, namely,

1. Logistics are a national responsibility.
2. Fresh food as long as possible.
3. Supply with food takes place by echelons (base-depot —— army corps supply point —— brigade supply point to the units.
4. Units have a minimum stock of five days combat-rations.
5. Supply lines are relatively short (about 300 km).

A distinction should be made between the supply with food in time of peace and time of war.

Time of peace

In peace time a difference should also be made between food supplies in the garrison and supplies of class I during exercises.

1. I presume that food supplies in the garrison will be familiar to you, therefore I am not going into this matter in my presentation.

2. On the other hand fresh food is brought up to the unit during exercises and has to be prepared in the field-kitchen.

Time of war

Starting points:
- Stock-piling is impossible for the units.
- Support will be on a day-by-day base.
- In general food-stuffs have a (factory) garanteed shelf-life of minimum two years after the date of production, but practically all items remain good for about 4 years. In principle all stocked food-stuffs have to be renewed between the 4th and the 5th year.

Methods of supply: 1. If the field-kitchen can be used and it is possible to bring up fresh rations it is preferable to use these rations.

2. If the field-kitchen can be used and it is not possible to provide the units with fresh rations we shall have to use field-rations.

3. If even the field-kitchen cannot be used we shall have to use combat-rations.

NL OPERATIONAL RATIONS

The NL operational rations in use at the moment cover 4 categories:

1. Field-rations.

2. Combat-rations
   a. group (10-in-1) ration
   b. individual ration.

3. Emergency-rations.

4. Special rations.

Re 1 - Field-rations (Practically equivalent to the US-B-Ration)

Conditions of use:
When food has to be provided for large groups of men and when
- fresh food-stuff (additional non-perishable items) can be brought up
- field-kitchens can be used
- prepared meals can be issued or brought up.

Particulars

- The items in the field-rations correspond largely with those of the peacetime rationscale. The authorized quantities are, however, somewhat higher in view of the possibility of distribution losses.
- The gross energy value is:
  - 4.000 kcal approx. per man per day
  - 100 g of proteins per man per day
  - gross weight: ± 2 kg
  - price: ± fl 5,50
- The basic menu is made up centrally around the following framework:

Bread menu (2x a day)	Hot meal menu
Bread	Meat
Margarine/Butter	Vegetables
Luncheon meat	Potatoes
Cheese	Soup or dessert
Sweet bread-garnish	Fruit (every other day)
Coffee - Tea	

Remarks

- Bread is generally provided by civilian German and/or Dutch bakeries.

- Meat will preferably be supplied boned and will usually be deep-frozen.
- Vegetables will, whenever possible, be supplied cleaned and/or refrigerated or deep-frozen.

For use in the preparation of food "kitchen rations" are issued, containing condiments, farina, chocory syrup, (essance of) vinager.
In principle, field-rations must be composed of non-conserved components.
If tactical circumstances give rise to it, supply with pre-cooked rations can take place.
Use of the kitchen is only limited to heating these tins and to prepare coffee or tea.
In my opinion this work does not take much time and most of the units should always have the opportunity and time to do this.
Consequently all troops can be supplied with these rations, even those who are in the Combat Zone.

Re 2 - Combat-rations

Conditions of use
If field kitchen cannot be used and prepared meals cannot be brought op.

a. Group ration (10-in-1)   See for composition last page but one.

Food ready for consumption, for 10 men during 24 hours.
Packed in three stout cardboard boxes and consisting of:
- 1 box, containing 10 tins of 'complete meals'
- 1 box, containing 2.500 g of biscuits
- 1 box, containing miscellaneous items, 10 rations.

Only the heat-sterilized items are tinned, oll others are packed in a laminate.

Nutritional value (approx.):

- 3.600 kcal
- 100 g proteine
- 450 g carbohydrates
- 150 g edible fats
- Gross weight : ± 2½ kg
- Price : fl 7,50

Remarks

For heating these complete meals, solid fuel tablets (trioxane) are issued.

b. Individual ration (One man-food packet)   See for composition last page.

- Food, ready for consumption, for 1 man during 24 hours, packed in a single carton.
  This is designed for soldiers who are out of reach of field-kitchens and for special tactical situations and tasks and to be stowed on the person, either in pockets or in a haversack.
- Hot meal, cheese, fruit preserve and luncheon meat excepted, all items ar packed in a laminate: we are endeavouring to replace these last four tins by some sterilisable aluminium laminate.

Nutritional value (approx.)

- 3.700 koal
- 100 g proteine
- 490 g oarbohydrates
- 150 g edible fats
- Gross weight : ± 2 kg
- Prioe : ± fl 9,=

Remarks

Canned food (hot meals) oan be eaten oold in an emergency.
For heating purposes, eolid fuel tablete (trioxane) are issued.
The sweets are vitaminized and oontain 100 mg of aecorbin acid per 50 g ration. It hae been proved to be necessary to include this essential vitamin as tinned food will lose part of their vitamin C oontent in eterilization.

Re 3 - Emergency rations

Food for one man, iesued on an individual basis.
Normal iseue: emergency ration for use when the fighting units cannot be provided with food in any other way. It ie part of the permanent equipment of every soldier and ie suitable for use in any survival and emergency eituation and to bridge a short period of lacking eupply.
Recipe and compoeition did not change for many yeare.

Nutritional value (approx.) per ration of four bars of 50 g each

- 1.200 kcal
- 7 g proteins
- 100 g carbohydratee
- 90 g edible fate

The ration is composed of a mixture of cocoa, oooa fat, filler, coffee extract, milk powder and sugar, moulded into bars. The bare are individually wrapped in aluminium foil. The ration is issued in a carton holding four bars in a polyethylene bag.

Re 4 - Special rations

a. Special ration for long-range patrol (US-ration)

Nutritional value (approx.)

- 3.200 koal
- 100 g proteins
- 450 g carbohydratee
- 112 g edible fate

The ration is paoked in a plastio bag and oan be eaeily carried on the body.
Because obtaining this ration from the NL oivil industry ie impoeeible, furthermore beoause of the relatively low cost prioe of thie produot in US, we deoided miust 1974 to prooure for the time being our requiremente from the US-ARMY.

Gross weight US-ration : Approx. 11 ounce
Price : $ 2,50
8 menu's, each provides ± 1.000 kcalories.

b. Pilots emergency ration (Norwegian type)

A special ration intended for use after an emergency landing as an addition to food to be found locally, or to make such food more palatable.

Nutritional value (approx)

- 2.400 kcal
- 90 g proteine
- 110 g carbohydrates
- 180 g edible fats

The ration is packaged to withstand heights up to 10.000 feet.

And this concludes my presentation. Mr. Spieksma will now concentrate on a review of the technological developments of our operational rations.

Thank you.

COMPOSITION OF A COMBAT RATION

GROUP RATION (10-in-1) — **Varieties of 'complete meals'**

HOT MEAL — 1 cardboard box cont. 10 tins:

peas/potatoes/minced meat
goulash/potatoes or rice
white beans/bacon/tomato sauce
marrowfat peas/bacon
kidney beans/bacon
rice/chicken/curry sauce
hotchpotch
macaroni/minced meat/tomato sauce

BREAD MENU (breakfast and lunch) + miscellaneous

1 cardboard box cont. 2.500 g — biscuits

1 cardboard box cont. misc. items:

10	bars of chocolate	50 g each
2	tins of instant coffee	50 g each
1	packet of tea	25 g
1	carton of sugar	750 g
2	tins of fruit cocktail	850 g each
1	tin of cheese	520 g
1	tin of fruit preserve	500 g
5	packets of soup	
1	tin of luncheon meat	350 g
1	roll of toilet paper	100 sheets
10	books of matches	20 sticks
10	packets of cigarettes	10 each
1	envelope cont. tin openers	2 pcs
1	tin of margarine	500 g
1	menu/list of contents	

The ration comes in 5 menus differing in the varieties of hot meals, luncheon meats, soups and fruit preserves (jams).

COMPOSITION OF A ONE MAN-FOOD PACKET

BREAD MENU (breakfast and lunch):	1 packet of biscuits x	125 g
	1 tin of luncheon meat	115 g
	1 tin of cheese	115 g
	1 tin of fruit preserve	35 g
HOT MEAL:	2 tinned hot meals	300 g each
	1 packet of instant soup	50 g approx.
MISCELLANEOUS ITEMS:	5 sachets of instant coffee	1,8 g each
	5 sachets of coffee-whitener	0,4 g each
	1 tablet of dried fruit	50 g
	1 sachet of instant tea	0,6 g
	1 sachet of instant beef tea	5 g
	10 packets, cont. 2 limps of sugar	0,4 g each
	2 packets of chewing gum	4 sticks
	1 sachet of lemon powder	30 g
	1 bar of chocolate x	50 g
	1 roll of vitaminized sweets	50 g
	1 sachet of salt	10 g
	1 packet of cigarettes	10 pcs
	1 book of matches	18 sticks
	1 sheets of toilet paper	
	1 tin opener	
	1 menu/instructions sheet	

The ration comes in 5 menus differing in the varieties of hot meals, luncheon meats, soups and fruit preserves.

x Packed together in a laminate bag, protected by a light carton.

TECHNOLOGICAL ASPECTS OF OPERATIONAL RATIONS

INTRODUCTION

As Lt. Col. Dumas just said in his introduction, I am Chief of the Bureau of technology class I, and as such responsible for the technological aspects of all foodstuffs for the armed forces. (The Army, the Navy an the Air-force).
Because of rapid technological developments in the food-industry, and considering the ever-increasing aspect of costs in the sphere of staffing in connection with the preparation of food in peace-time, a plan for the future for class I articles has been developed within the Material-Branch nr 7 of the Quartermaster-General in peace- and war-time.
It stands to reason that in relation to the composition of feeding in peace-time, changes in eating habits have to be followed closely.
With regard to the field rations, in the future, fresh food will be consumed as longas possible. An application of new practices and methods of feeding in peace-time will certainly find acceptance in case of supplying and composing field-rations.
The Quartermaster-General has not the disposal of a scientific institution of its own , but because of close governmental relations with the State Defence Organization and the Applied Natural Scientific Institution for Research RVO/TNO special assignments can be granted to suitable institutions in the field of research for nutritional value of new meals, or for the latest methods of supplying meals.

DEFINITIONS

FEEDING

Peace-time

The purpose of feeding servicemen in peace-time is to give them food that meets the present-day requirements, the science of nutrition and presentation, in order to reach an optimum physical condition.

War-time

The purpose of feeding in war-time is to supply the soldiers with food-packets as complete as possible, and considering the circumstances, these packets must meet the requirements of the science of nutrition and presentation and to be prepared with the available equipment in order to keep the soldier fit.

To start from these two objectives I would like to say something about:

1. FEEDING IN PEACE-TIME

   More and more preparation work must be put out to contract. The first steps in this direction have already been made. Experiences are now being gained on a limited scale with:
   - technical and portioned meat
   - peeled potatoes.

In the Netherlands, for some years, potatoes have been peeled and packed in factories, who specialize in it.
This year experiments have been made on a larger scale with field-kitchens, with practising troops.
The problem that arises is how to keep peeled and packed potatoes fit for consumption under adverse circumstances. Outside the cold-store the potato is fit for consumption for only 24 hours.
It is known that the industry works at a procedure by which the peeled potato gets another extra treatment in order to attain a better protection against deterioration of the potato.

- Cooked, vacuum packed potatoes are now on sale on the European market.
  Wrapped in aluminium foil, keeping qualities of one year is guaranteed, without special storage facilities.

- Deep- frozen meals (components)
  Especially, when preparations are made for the construction of kitchens, or the reconstruction of the existing ones, the question arises, whether to make use of industrial prepared meals and components. The same question arises with institutions, hospitals etc., but they have been tackling this problem earlier.
  From researches made, only recently, into the quality of deep-frozen meals, it has appeared that quality and presentation are susceptible for improvement.
  From a food-technical viewpoint the too low caloric value must not be overlooked.
  When feeding with extra portions of potatoes of milkproducts is concerned, it is necessary to ingest fixed quantities calories a day.

2. FEEDING IN WAR-TIME

In Lt. Col. Dumas lecture, you have just heard about the starting-points of feeding in war-time.
Therefore, it is of paramount importance, that experience is being gained with, as I already mentioned, partly prepared products.
For that reason the Quartermaster-General has set up a committee in which, besides our representatives, industry and science are also represented to find out as to how far, among other things, deep-frozen meals (components) can also be used in war-time.

Canned food

The consumption of canned food must be delayed as long as possible, and only to be supplied when the situation necessitates to do so, for replenishment of these stocks cannot take place at short notice.

Field-ration

The starting-point of the development of these rations is the high demands we made on the soldier in war-time. The conditions run as follows:

Nutritional value

The quality of the raw materials and the quantities to be consumed have been prescribed.

Packing and storage

The field-rations to be stored in peace-time are packed in tins. The quality of the sheet-steel is prescribed. Under the influence of various economic factors, we are forced to use tins in accordance with current European standards. The development of new varieties of lass has resulted that our requirement, the period of storage, that is to say, the manufacterer guarantees a keeping quality of two years (after the date of production) by which, the Quartermaster-General stores these rations for another two years, can be met. The question arises whether we must change into normal packing and unit of weights.

Exterior packing

High demands on exterior packing are and will always be made (transhipment, transport, stapling, climatic influences.

Weight and volume

As a result of modern-transport-system of the units, the conveyance of class I articles, the weight of the field-rations and group-rations (10-in-1) does not play a great part. Considering the small loading capacity of foodstuffs a decrease of volume remains a pre-requisite. In cooperation with the Central Institute of Nutrition, we are looking for concentrated meals, so less voluminous. However, it has appeared, that this is no simple task. In this connection, we are thinking of a rice and macaroni dish.

Individual ration (One man food packet.)

One of the conclusions after the meeting on food for the armed forces in Oslo in 1972 made by the Dutch representatives was to replace tin packing by aluminium foil. The first change we made in the composition of the "one man food packet" is to replace the tins, and in particular the 1 litre tin (contents, about 850 grams) by two flat trays (nett contents, 360 grams each). This change has given a saving of weight and volume. From a technological viewpoint an improvement has been made, which has increased the acceptance of the product. This smaller packing enlarges the choice of hot meals; it facilitates the heating and it prevents that packings, once opened, should be carried along. An important decision that results from this packing is the abolition of the army's green colour.

The various hot msals will be applied to new tastes regularly. Food experts and research institutions ars indispensible in this. This one man food paoket contains one tin of luncheon meat of 115 grams. For the Dutch industry, the tin industry as well as the meat industry, this is an impossible size. The present filling and locking machinery are no longer adjusted to 115 grams, but to 100 or 200 grams and higher. Owing to this, production and technical problems arose and this was the reason, that the decision was made to change over to the custumory tin size.
A closer study is necessary to introduce the smaller rigid packings of 30 and 40 grams, through which a larger assortment is possible for the individual ration.

I do not want to end before making an urgent appeal to all of you to cooperate and to exchange views on the latest developments in the field of packing and technology.

DANISH SYSTEM OF OPERATIONAL RATIONS

by

Lt.Col. Ejvin Lareen
Director of Supply Divieion
Danieh Army Materiel Command

Yesterday the Danieh eenior veterinarian, Col. H. Saee, preeented a paper on the nutritive value and the effecte of storage on operational ratione. Thoee who were pressnt will know that the Danieh army'e field catering service coneiste of individual rations, baeed on cannsd meals.

The reasone for thie are fourfold:

1. Denmark is a very emall country, located at a etrategic focal point (The Baltic Approachee). It may therefore bs aseumed that any engagement in battle of Danieh troope will be of relatively ehort duration.

2. Denmark is a cloeely populated country; mesehall and cafeteria facilities are excellent and well distributed throughout the country.

3. The emaller an army is, the greater ie the neceeeity for reduction of auxiliary services (such as kitchen units) in order to increase the percentage of fighting men.

4. The Danish eating habits make a "lunch and dinner bag" solution poesible and acceptable for the soldiers.

Even though these conditions are hardly met by any other country represented at this meeting, it may still be of some interest to hear how we have solved the problem of feeding a hungry army.

Our firet approach ie to feed the units as long as poesible in meeshalls and cafeterias; and in our opinion some rear unite can be fed this way in most circumstances.

When cafeteria-feeding ie no longer poseible we turn to our eo called "F-rations". One F-ration contains about 3,800 calories which ought to satiefy even a great Dane for a day'e time. As not all ingredients keep equally well it has been found practical to divide the ration into:

- A "non-perishable" F1-allowance (minimum 3 yeare; in practice eaeily 5 years' etorageability).

- A "periehable" F2-allowance (6 months under normal storage conditions).

- An F3-allowance, which coneists eimply of margarine which must kept under rsfrigeration; and laetly

- An F4-allowance of bread which is procured locally as required.

The F1-allowance consiete of the iteme ehown in table 1. The two firet iteme are 300 g (10½ oz.) canned msale of excellent quality. One is a traditional dinner type, suitable for supplement with mashed potatoes; the other is a luncheon type meat dish, normally eaten with bread. The liver paste was once removed from the ration but hastily added again to avoid mutiny in the Danish armed forces. (Due to American import regulations, liver paste has been replaced with mackerel in the 40 rations supplied for this conference.)

The menu varies as new and attractive products are developed by the civilian industry; but it must be noticed that the army rations have a higher meat content than the products sold on the civilian market. Presently we carry some twenty different dishes, thus offering ten different F1-allowances, each under their stock number. It is the obligation of the using units to ensure a variety of food for the individual consumer.

The F2-allowance contains the items shown in table 2, namely the mashed potatoes, a dessert, crackers and a selection of bread spreads, all - as mentioned before - ingredients with a somewhat limited lifetime. The variation is ensured by the use of presently:

10 different desserts,
5 meat or fish spreads,
5 cheeses, and
4 marmelades.

However, at any one time, only 5 types (marked "F2-A, -B, -C, -D, -E and -F") are "marketed", and they all carry the same stock number. Each carton of 10 rations contain two of each type, and the variation is obtained by "swapping" between individual consumers - hopefully in accordance with everybody's taste.

As you may know it is a Danish habit to use a slice of buttered bread as the basis for an open face sandwich ("smørrebrød"). This is the reason for the F3-allowance, which consists of 70 g (2½ oz.) margarine of a quality that favorably compares with butter. The durability is of course very limited and we are obviously interested in new developments in this field.

The F4-allowance consists of 7 slices at a total of 21o g (7½ oz.) rye bread of the pumpernickel-type. This type of bread appeases the hunger of all Danes every day, and without it we would not have been vikings. Luckily it is a compact, reasonably durable, healthy eating and is obtainable in every village in packs of this size. In southern Jutland they sell a variety that is even worse.

To enable the troops to heat the food, all vehicles carrying personnel are equipped with a camping type gas stove. Personnel who have no access to a gas stove are equipped with a small pliable stove, using Hexamethylene Tetramine tablets as a fuel.

It is the policy of the Danish Army Materiel Command not to perform industrial functions that can be bought on the civilian market, but strangely enough it has proven impossible to make any civilian company interested in supplying ready-made rations. We therefore do the packing ourselves, and as a matter of fact this job fits in excellently at a depot as a means of smoothening the workload. One of our workshops has designed and built a rather simple but excellent packing line. Whenever the need arieee and/or the manpower ie available a crew is put together, and in a matter of one or a few houre the ratione required are packed. At another depot with very limited pereonnel etrength they eimply pick up the phone and oall one and a half dozen houeewives up ae temporary etaff whenever needed.

The Danieh Army Materiel Command wae aeeigned the Claee I eupply miesion in 1974, and I am proud to eay that by thie flexible way of operation we have been able to cut the manpower ueed on the eupply of operational ratione by 60 per oent.

The peacetime requirement ie of couree limited to exercieee and maneuvere, eo we muet be able to etep our production up dramatically in caee of an alert. Needleee to eay that we are prepared for that eituation.

Finally I must mention that our eyetem aleo comprieee a K-ration for emergency use. However, it doee not eeem poeeible that anyone would be ehort of food in Denmark, and the K-ration ie therefore ieeued only to pereonnel on epecial mieeione. The preeent K-ration ie coneidered outdated, and we are intereeted in newer and better producte.

This concludee my preeentation. I will be happy to anewer any queetione to the beet of my ability.

TABLE 1

F1 - ALLOWANCE

Ingredients	Unit per Allowance
Dinner, canned	1 can
Lunch, canned	1 can
Liver paste	1 can
Coffee, instant	2 envelopes
Tea	1 envelope
Sugar	3 packages
Salt	2 envelopes
Pepper	1 envelope
Napkin, moist	2 each
Napkin	10 each
Matches	1 box
Chocolate drink, instant	2 envelopes

TABLE 2

F2 - ALLOWANCE

Ingredients	Unit per Allowance
Potatoe, mashed, instant	1 package
Fruit, canned	1 can
Cheese, spread	2 each
Marmalade	2 each
Meat or fish, canned	1 can
Crackers	1 package

TABLE 3

F3 - ALLOWANCE (Cooled)

Ingredients	Unit per Allowance
Margarine	1 package (70 gram)

TABLE 4

F4 - ALLOWANCE (local purchase)

Ingredients	Unit per Allowance
Pumpernickel	1 package (210 gram)

MEAL, READY-TO-EAT, INDIVIDUAL
LATEST U.S. OPERATIONAL RATION

By

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MEAL, READY-TO-EAT, INDIVIDUAL
LATEST U.S. OPERATIONAL RATION

Combat rations - the mention of subsisting on them brings a variety of recollections to those that have eaten them under varying conditions and for varying lengths of time, be it in WW II or in conflicts since that time.

Operational rations are designed for Military utility, stability, safety, nutritional adequacy and acceptability - and frequently in that order.

When, of necessity, the emphasis is put on the first of these (utility and stability), acceptability frequently leaves something to be desired. Developing a Combat or Operational ration that truly meets all of the users needs in reality means assessing many approaches and making trade offs. For example, knowing that the ration(s) must frequently be carried on the individual soldier's back along with many other critical items, the weight of the ration must be kept as low as possible consistent with the other criteria for utility, nutritional adequacy and acceptability. It is thus immediately obvious that trade offs must be made if a ration is ever to be brought into the system. Most often, however, these trade offs really reflect the best application of the technology available.

The goal or target then is to make only those trade offs which will make the ration best suited for its intended purpose. For example, we know that many times combat rations must be eaten cold; therefore acceptability of the ration under these conditions will be lowered. We then try to develop foods that are as acceptable as possible when eaten cold knowing that the acceptability will be better when the item is eaten hot.

When the Meal, Ready-to-Eat (MRE) was conceived some 17-18 years ago, our goal was to have a ration that would meet all the Military and Technical characteristics - lightweight, easy to carry on the person, etc. and still have it more acceptable than any other combat ration. We planned to push the "state-of-the art" to achieve this goal.

We planned to investigate all methods of food preservation: heat, freeze drying, irradiation and others that might be available as the ration was under development. One of the very early bench top prototypes contained irradiated orange slices in a flexible pouch to illustrate our intent to explore all new approaches in the development of this ration.

The Army Test and Evaluation Command found that "The test meal better meets Army requirements than the standard Meal, Combat Individual." (1) This ration has now been type classified, and it is expected that the first large scale procurement will be underway within the next few months.

All indications were that this new operational ration met all the Military and Technical characteristics established for it, and approved in 1961, except for mass (weight). These characteristics are shown in Attachment 1. What might be called trade offs were made to meet requirements; however these really were the application of the best technology available, and did not impair the overall quality of the ration. For example, freeze-dried fruits and freeze-dried, deep-fat-fried pattie items were used to keep the meal weight as close to the target weight as possible. The freeze-dried fruits can be eaten out of hand or rehydrated in the pouch with cold water. The same is true of the potato, beef, and sausage patties. Even though it was planned to use irradiated items as they were developed, the lack of U.S. Food and Drug approval of sterilized products suitable for this ration has prevented inclusion of suitable irradiated components. When F.D.A. approval is obtained, it is expected that such items as beef, ham or chicken slices will be included.

All of the metal cans typically found in U.S. Combat rations have been eliminated. All of the thermally processed items are in retortable, flexible pouches.

Dr. Lampi will go into considerable detail on the retortable pouch in his paper which follows later in this session.

The development of this ration has been long and difficult because we have been at the forefront of technology. It has involved the team work of both food and packaging technologists. For example, there are 7 different kinds of cakes which are fully sterilized in the pouch. This necessitated completely new product technology and control of the thermal process in order to have an acceptable product. The "wet" meat items also required extensive product development.

As a result, we have a variety of excellent products to make up the various meals. From the products available 15 menus were designed.

Typical menus are shown in Figures 1 and 2.

The target weight for each meal was 454 grams, a reduction of some 409 grams from the present meal combat individual (MCI). The elimination of the metal cans brought the weight down considerably, but replacement of the cans with flexible pouches did not by itself give a means of meeting the caloric requirement (1135) and good acceptability within the desired weight limitations.

Further weight reduction was obtained by combining certain freeze dried components with typical "wet" components such as the thermally processed meat items. If a typical "wet" fruit component such as crushed pineapple was used, it was combined with a freeze-dried pattie item - beef or sausage. As pointed out previously, the freeze-dried items can be eaten out of hand or rehydrated and eaten from the pouch.

The test report (2) indicates that by this type of meal design the weight was brought down to approximately 538 grams. This was some 90 grams over the target of 454, but 314 grams less than the present Meal, Combat Individual (MCI). Within the present "state-of-the art" we could not meet the target weight, but we have taken 36% of the MCI weight off the soldiers back. In addition, we have made it a lot easier to carry (flexible pouch versus metal can) and markedly improved acceptability.

Figures 1 and 2 show typical combinations of freeze-dried and thermally processed items used to keep weight as near target as possible.

The nutritional content of operational rations is of course important, and regulations cover requirements for calorie levels, as well as protein, calcium, iron, and vitamins. The values as obtained on the test meals are shown in Figure 3. The average number of calories from fat calculates to be just under 40%, which was the target. Nutritive values for typical components are shown in Figure 4.

During the field testing, some 21,000 meals were consumed under temperate conditions, and some 5,500 were consumed under Arctic conditions. Different types of troops were used in all tests. The various test groups consumed the meal for 1, 3 and 7 days. Throughout the testing, the soldiers consistently showed a very strong preference for the test meal consumed both hot and cold in comparison with the standard MCI. No monotony effect was shown over the 7 day period.

The test meals were scored by those consuming them using the 9 point hedonic scale. (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely). The test report shows that an average hedonic rating of 8.02 was given to two of the flexibly packaged, thermally processed meat components when eaten hot - beef slices in barbeque sauce and meatballs in barbeque sauce. These ratings are very high considering that each represents an average of 300 ratings. By comparison fresh milk, which is at the top in military food preference surveys and also at the top of the frequency of serving list, is likewise rated in the "like very much" range by soldiers. (3) When some 150 ratings were averaged, these same two items (beef in barbeque sauce and meatballs in barbeque sauce) eaten cold were given ratings of 7.71 and 7.72 respectively. The average rating for the other 13 meat components ranged from 7.18 to 7.97 (consumed hot), and 6.95 to 7.62 (consumed cold).

Comparisons with the present MCI are difficult because the components of the MCI do not have comparable items in the MRE. However, the ratings given to the MCI meat components consumed cold ranged from a low of 5.48 to a high of 7.36. These same components had a low of 6.14 and a high of 7.47 when consumed hot.

Although some decline in ratings is to be expected when an item goes into full scale commercial production under competitive bidding, it is believed that we have achieved one of our early goals - a highly acceptable combat ration, while at the same time reducing its weight by over 30% and substantially improving its overall utility. Furthermore, our storage tests indicate that this ration should have considerably better acceptability than the present MCI. Data available after 18 months at three typical storage temperatures: +4°C, +21°C and +38°C, show that typical entree items are still being rated in the like slightly (6.0) to like moderately (7.0) range.

Components of this new ration will be served at luncheon during the conference.

REFERENCES

(1) Letter, AMSTE-BC, HQ, TECOM, 30 July 1974. Subject: Evaluation of Meal, Ready-to-Eat, Individual, TECOM Project No. 8-EI-925-000-003.

(2) Development Test II (Service) (DT II-ST) of Meal, Ready-to-Eat, Individual, TECOM Project No. 8-EI-925-000-003.

(3) Meiselman, H.L., Watorman, D., and Symington, L.E. Armed Forces Food Preferences. U.S. Army Natick Laboratories Technical Report 75-63-FSL, December 1974.

MILITARY CHARACTERISTICS
FOR
MEAL, READY-TO-EAT

Statement of requirements -

Meal, Ready-to-Eat, Individual (U) - Individual meals, ready-to-eat, containing only quick-serve precooked dehydrated, and irradiated components for use up to one week in the combat zone. Components should be highly acceptable when eaten cold. No preparation required. Normal supply of drinking water must be available. Packaging should be lightweight and also suitable for use in place of mess gear. Reference CDOG, paragraph 1439f(16).

Operational concept -

The individual, ready-to-eat meal will be used to feed troops at times when it is impractical to provide other means of subsistence.

Organizational concept -

The individual ready-to-eat meal will be distributed to individuals and will require no preparation other than opening of packages, except for beverages; a small amount of water will be required to reconstitute drinks.

Background -

In the future Theater of Operations, the actual or potential use of nuclear weapons will require increased dispersion of units and supplies and highly fluid, mobile operations. In consonance with these concepts, the efficiency of supplying operational rations must be increased. Specifically, operational rations are required which will permit:

a. Reduction in the number of food service personnel and kitchen equipment required for preparing meals, as well as reduction in the training level required of food service personnel.

b. Substantial reduction in refrigeration requirements.

c. Feeding of troops over an extended period with an adequate and tasteful ration.

d. Reduction in requirements for transport, storage areas, handling equipment and supply personnel. New developments in dehydration and irradiation techniques of food processing provide a means for obtaining operational rations which meet the requirements of these new concepts of organization and tactics.

Attachment 1

Configuration -

a. Packaging shall be compatible with the pockets of field clothing.

b. Shall be of minimum weight and bulk consistent with other requirements. Gross weight will not exceed 1 pound.

c. The case in which the meals are packaged shall be of minimum weight and bulk consistent with other requirements. Gross weight will not exceed 25 pounds.

d. Components shall be packaged to the maximum extent in flexible containers.

Performance -

a. Shall provide an adequate quantity of food for one man for one meal, all meals to be essentially equivalent in nutrition so that any three meals will constitute a ration.

b. Shall be acceptable for consumption over a period of one week as a sole diet.

c. Shall conform to nutritional requirements.

d. Shall be acceptable when consumed hot or cold.

e. Shall require no preparation other than opening packages and shall require no water except for the reconstitution of drinks.

f. Shall include all accessories necessary for consumption of the meal, except canteen, canteen cup, and water.

g. An accessory packet containing cigarettes, matches, toilet paper, chewing gum, and cleaning patches will be included with each meal.

h. An expendable means of heating the meal will be provided.

Durability and Reliability -

a. Cases and packages shall be water, insect, and rodent resistant.

b. Cases and packages shall be marked, and markings shall remain legible under all conditions encountered in storage, transport, and distribution.

c. Shall be capable of withstanding military handling during transportation and storage prior to use.

d. Cases and packages shall be easily opened. If an opener is required for this purpose, it will be provided with each meal.

e. This ration shall be capable of storage without refrigeration for a minimum of 2 years (a longer period is desirable) without spoilage or detrimental decrease in nutritional value or palatability.

Transportability - Cases in which the rations are shipped shall be:

a. Suitable for all means of transportation including animal pack and man-carry.

b. Capable of aerial delivery by parachute.

c. Capable of aerial delivery without parachute with assurance of 75% recovery.

TECHNICAL CHARACTERISTICS
FOR
MEAL, READY-TO-EAT

General -

a. Scope: These characteristics pertain to the technical aspects of the development of the Ready-to-Eat Individual Meal to fulfill the military characteristics of operational rations.

b. Non-common characteristics: Technical characteristics provided herein pertain to the Meal, Ready-to-Eat, Individual, only and, in general, are not common to other operational rations.

c. Using elements: Theater of operations.

Design - The Meal, Ready-to-Eat, Individual, will meet the following design standards:

a. Nutritional adequacy: Meals will be designed so that any three provide the daily nutritional requirements set forth in AR 40-564 for one man, and any one meal provides 1/3 the daily nutritional requirement for one man.

b. Acceptability: At least 12 meals will be designed so that any one meal is suitable for breakfast, dinner or supper and any three are suitable as a ration. Food components will be developed in terms of maximum acceptability when eaten cold; variety will be sufficient to avoid rejection when the Meal, Ready-to-Eat, Individual, is consumed as the sole diet over a period of one week. Human engineering principles will be applied throughout development of food components.

c. Stability: All food components, in the packaging used for the Individual Ready-to-Eat Meal, will be capable of withstanding at least six months at 100°F. without significant loss of nutritional adequacy, edibility, acceptability or utility, and will be capable of withstanding repeated freezing and thawing involving exposure, in the ration case, to temperatures as high as 125°F. for as long as two hours per day, and as low as minus 65°F. without significant loss of nutritional adequacy, acceptability and utility.

d. Utility: The meals will require no preparation other than opening of packages and no reconstitution except of beverage components. Lightweight packaging capable of use as a heating vessel under conditions permitting heating will be used. The meal package will contain all accessories needed for consumption of the meal except canteen, canteen cup and water. Gross weight of each meal will not exceed one pound; gross weight of packed shipping containers will not exceed 25 pounds. The configuration of each meal will be compatible with pockets of field clothing. Cases in which the meals are packed will be designed for aerial delivery without parachute with assurance that 75% of the contents will be suitable for consumption within 24 hours after the cases are dropped on representative terrains at speeds and from altitudes normally used by Army rotary and fixed wing aircraft in support of tactical operations.

Components - The Meal, Ready-to-Eat, Individual, will consist of 12 meals in lightweight packages containing all required accessories and materials needed to prepare and eat the meals except canteen, canteen cup and water. An expendable means of heating the meal will also be provided separately and not as a meal component. The food components will be processed by whatever methods prove most successful in meeting the military characteristics; maximum use will be made of precooked foods processed by novel or improved thermal or other relevant methods; when the state of the art permits, precooked radiation processed components will be included.

SELECTED MENUS
OF
MEAL, READY-TO-EAT, INDIVIDUAL

PORK SAUSAGE PATTIES	FRUIT MIX
PINEAPPLE (WET)	BEEF STEW
CRACKERS	CRACKERS
CHEESE SPREAD	PEANUT BUTTER
COOKIES, CHOCOLATE COVERED	CHERRY NUT CAKE
COCOA	COCOA
CATSUP	COFFEE
COFFEE	CREAM SUBSTITUTE
CREAM SUBSTITUTE	SUGAR
SUGAR	

FIGURE 1

SELECTED MENUS
OF
<u>MEAL, READY-TO-EAT, INDIVIDUAL</u>

BEANS IN TOMATO SAUCE	MEATBALLS IN BARBECUE SAUCE
BEEF PATTIE	POTATO PATTIE
CRACKERS	CRACKERS
CHEESE SPREAD	JELLY
BROWNIES, CHOCOLATE COVERED	CHOCOLATE NUT CAKE
SOUP AND GRAVY BASE	COCOA
CANDY BAR	COFFEE
COFFEE	CREAM SUBSTITUTE
CREAM SUBSTITUTE	SUGAR
SUGAR	

FIGURE 2

RECORD OF NUTRITIVE VALUES MEAL, READY-TO-EAT, INDIVIDUAL										Date 6 OCTOBER 1975				
Ration Item	Weight		Water	Energy	Protein	Fat	Carbohydrate	Calcium	Iron	Vitamins				
										A	C	Thiamine	Riboflavin	Niacin
	oz.	gm.	gm.	cal.	gm.	gm.	gm.	mg.	mg.	I.U.	mg	mg.	mg.	mg.
Menu No. 1	12.85	364.36	104.9	1274	35.6	56.2	155.7	480	5.6	5070	95	3.16	1.42	7.[illegible]
No. 2	12.67	359.45	115.2	1157	50.4	52.4	132.7	212	5.8	2500	91	1.28	1.00	22.[illegible]
No. 3	13.74	389.41	119.1	1322	50.4	61.1	143.8	516	9.6	3950	55	1.80	1.32	10.[illegible]
No. 4	12.49	354.06	100.2	1213	44.7	52.7	145.8	258	6.0	3170	61	1.71	1.09	15.[illegible]
No. 5	14.12	400.52	127.4	1292	39.9	57.4	165.0	286	5.8	7150	93	2.10	1.18	13.[illegible]
No. 6	16.24	460.28	182.6	1316	40.6	53.1	170.6	357	8.7	3140	61	1.44	1.23	8.[illegible]
No. 7	14.07	399.10	130.4	1290	44.2	51.6	167.1	279	5.3	2500	54	1.32	1.22	9.8
No. 8	15.45	438.04	211.3	1157	47.8	58.0	109.8	469	8.8	2900	52	1.70	1.22	7.9
No. 9	13.12	372.14	123.8	1182	52.8	45.1	139.4	478	7.6	5070	95	2.07	1.41	10.6
No. 10	14.07	399.10	114.1	1332	35.5	56.6	180.5	291	6.6	3020	54	1.33	1.29	8.0
No. 11	13.37	379.31	111.8	1273	47.0	56.4	150.8	499	5.6	5220	95	2.32	1.53	9.5
No. 12	12.54	355.48	96.6	1255	53.9	57.6	139.5	269	5.3	2670	94	1.65	1.23	15.8
Total	164.73	4671.26	1537.4	15063	542.8	658.2	1802.7	4394	80.7	45470	900	21.89	15.14	140.4
Average	13.73	3[illegible]9.27	128.1	1255	45.2	54.8	150.2	366	6.7	3790	75	1.82	1.26	11.7
Minimum Meal Requirements				1133	33.3			267	4.7	*1670	20	0.57	0.67	7.3
(1/3 Ration Requirement						* One	third	of which	must	be preformed Vitamin A				
Prescribed by AR 40-25)														

AMRRE Form 709 (3 parts)
3 August 1966

FIGURE 3

RECORD OF NUTRITIVE VALUES — Date 6 OCTOBER 1975

Ration Item	Weight oz.	Weight gm.	Water gm.	Energy cal.	Protein gm.	Fat gm.	Carbohydrate gm.	Calcium mg.	Iron mg.	Vitamins A I.U.	Vitamins C mg.	Thiamine mg.	Riboflavin mg.	Niacin mg.
Frankfurters	4.75	134.66	75.9	384	20.5	32.0	1.7	28	2.8	---	---	0.04	0.23	4.3
Chicken Loaf	5.00	141.70	90.3	(258)	32.6	11.6	5.7	31	1.7	---	---	0.01	0.30	6.1
Beef and Gravy	5.00	141.70	95.9	256	24.4	15.6	3.3	18	3.1	---	---	0.03	0.24	3.8
Pork Sausage Patties	1.40	39.69	0.6	(225)	18.4	15.7	2.7	9	1.3	---	---	0.66	0.13	3.9
Cherry Nut Cake	3.17	90.00	16.3	355	3.9	16.8	51.8	46	1.1	---	---	0.05	0.10	0.5
Cookies, Choc. Covered	1.50	42.53	0.6	(217)	2.5	10.3	28.4	36	0.7	---	---	0.10	0.30	0.8
Peaches, Dehy	0.75	21.26	0.4	74	1.0	tr	19.4	5	0.3	220	6	0.01	0.02	0.7

AMXRE Form 709 (3 parts)
3 August 1964

FIGURE 4

MORE UNIFORMITY OF SPECIAL RATIONS

by

Colonel O M Jørgensen

Quartermaster General, Norwegian Army

Introduction

1. It is now three years since the last meeting on "Foods for the Armed Forces" was arranged in Norway, and it is in the hope of gaining further valuable professional profit that we accepted the invitation to participate in this 3rd meeting. It is our belief that this form of contact and exchange of ideas and experiences are very useful.

2. Feeding military forces in the field is - within NATO - in principle a national military responsibility. The practical execution of this service varies and is to a large extent governed by each nation's eating habits. As long as this service can be carried out according to plan and assumption, everything is ok.

3. Most nations have, however, special routines and rations which are intended to satisfy the needs of their soldiers under especially difficult and unexpected conditions. It is within this field that our experiences from NATO exercises in peace-time indicate that in a real conflict we will have to face far greater problems. We think that in situations where the routine logistic service is difficult to maintain, there may be a strong need for mutual support between units from different nations. Concerning such a fundamental supply article as special rations, we should therefore - to a greater extent than hitherto-keep in line with each other in order to facilitate the use of each other's resources if need should arise.

The Problem

4. The matter has previously been dealt with by The Military Agency for Standardization (MAS, NATO) who initiated a study carried out by The Central Army Group, Mannheim (CENTAG, NATO).

   This study resulted in a list comprising the special rations of various countries with designation, area of usage, calorie contents etc. The list has been approved by NATO as a "Standardization Agreement".

5. However, it cannot be considered as any real standardization, rather a registration of existing conditions. We belive that it is both desirable and possible to develop this matter further towards a greater conformity in designation and area of usage.

I should therefore like to comment upon three factors which are important to make my point clear.

<u>Nomenclature</u>

6. The Central Army Group's study referred to, shows that within NATO there are more than 20 different terms for special rations. Some terms suggest area of usage, others supplements, whereas a few terms are rather vague. A summary of closely related terms still gives 11 different possibilities of choice as shown on this slide.

7. Here we see that a number of nations has at least the following two terms in common:

COMBAT RATION and

SURVIVAL RATION

The other terms are mainly used by single nations.

Can we assume that here lies a possibility of standardization based on two main designations or areas of usage?

<u>Area of usage</u>

8. The area of usage is decisive for the composition of rations, calorie contents and partly also designation.

The considerable defferences between the various countries are here noticeable. Several countries have concentrated on general and comprehensive areas of usage where one or two different rations satisfy several needs. Other nations have a variety of different rations, the use of which is dictated by more specific needs.

9. These differences may be accidental, but most of them are probably based on substsntially divergent needs. Some people will maintain that these divergent needs - which must be satisfied - will hamper a further standardization.

I do not absolutely agree to this. If we consider the area of usage in connection with the designation, we should be able to imagine a common main designation which everybody can accept, with sub-designation indicating a more spicific usage.

10. By way of example one ought to imagine

COMBAT RATION

as a collective term for rations used under conditions where more normal feeding in camp or from field kitchen is not possible or practical.

A sub-title may indicate a more specified area of usage, e g.

COMBAT RATION (Paratrooper) or

COMBAT RATION (4 men 1 day)

COMBAT RATION (Arctic)

In this way it will be possible to keep the arrangement - which the various nations have adopted to satisfy their primary needs - and at the same time to create understanding for the idea that enlarged areas of usage is possible, if need arises.

Contents

11. In discussions about standardization of the specific rations, the question of contents is probably the most difficult one. National diets and the areas of application will decide the contents and structure of the rations. In my opinion it is not advisable to alter these factors very much through standardization.

I think, however, that one ought to agree to a lower and possibly also an upper limit of nutritive value. For instance, one day's COMBAT RATION for one man could be given a nutritional definision which secures one day's substantial diet, independent of differences in eating habits and specific criteria of usage.

12. Conclusion

Through these simple reflections, I have tried to illustrate the need for a more standardized version of special rations.

It is our view that needs and tecnical development will still bring about further progress within this field. We ought therefore to agree on certain common standards with a view to creating a better foundation for supporting each other mutually in practical situations.

If we, through such a standardization scheme, could agree on

- a common main designation
- supplementary designation according to needs, and
- common guides for nutritive contents

much would be won. Could we also furnish our rations with derections for use in for instance English and French besides the national directions for use, the practical results of such efforts would probably be secured.

13. I suggest that the question be submitted to "Army Board" for further consideration by a special committee within "Logistics Working Party".

DRAFT STUDY OF SPECIAL RATIONS

NOMENCLATURE	CAL PER RATION LOWER	CAL PER RATION UPPER	WEIGHT PER RATION IN KG LOWER	WEIGHT PER RATION IN KG UPPER	USER NATIONS
1 COMBAT RATION	2,600	4,500	1,0	4,4	BE/CA/FR/GR/IT/NE/NO/TU/US
2 SPECIAL COMBAT RATION	4,700	5,000	1,8	4,6	IT
3 SURVIVAL RATION	870	1,200	0,2	0,6	BE/CA/FR/GE/NE/US
4 EMERGENCY RATION		900		0,15	UK
5 FOOD PACK RATION		830		0,28	CA
6 PACKED FIELD RATION	3,600	4,500	2,4	2,5	DF/GE/NE
7 FOOD PACKED LONG RANGE PATROL		1,100		0,31	CA/US
8 COMPOSITE RATION		4,000		2,72	UK
9 ASSAULT RATION		3,330		0,90	UK
10 MEAL COMBAT		3,600		2,8	US
11 RATION SUPPLEMENT ARTIC		1,000		2,12	CA

Flexible vs. Rigid Packaging

for

Operational Rations

RAUNO A. LAMPI

In the beginning; that is, the late 1950's, when a need to seek improvement in the packaging of the standard U.S. operational ration was initially voiced, the fundamental comparison of flexibles vs. rigid containers was made. It was decided that the hardness and awkward shape of the 300 x 200 cylindrical, 3-piece sanitary can were undesirable. Many other attributes of the rigid can, and the nature of its contents - its durability and excellent safety record for preserving high water activity, ready-to-eat foods - were highly acceptable and retained as essential criteria for the development of potential replacements.

The result has been the retort pouch - or Flex-Pack - that is the fundamental component of the Meal, Ready-to-Eat, Individual, previously described. This packaging-preservation concept has evolved into commercial reality in Italy, parts of Northern Europe, Japan, Canada, and perhaps by now in additional geographical locations. In the U.S., several companies were on the verge of initiating marketing tests, when the regulatory agencies invoked a review of adhesive-related extractives from the 3-ply laminate. The military is currently ready to buy significant quantities as soon as they become available.

When this concept was first considered, it was felt that neither the packaging materials available nor the techniques of laminating were adequate to meet the needs. Therefore, initiation of the project was delayed until our review of the "state-of-the-art" indicated a sufficiently high success potential.

Very early in our consideration of the new system a decision was made to use conventional steam or water cook retorts. Aseptic packaging was considered but at that point in time, very little was available in the way of heat exchange equipment for anything other than liquids or semi-liquid items. Equipment and techniques for sterilizing film materials and the subsequent handling of these films for this application were non-existent. Realizing that there were problems associated with packaging equipment, we chose not to add the additional problems associated with aseptic packaging. Steam and water cook retorts were the standard and were generally available in the plants of food processors.

Our study of the problems before us resulted in the identification of the following major technical requirements which the flexible package must meet.

1. Exposure to 121°C (250°F) in water or steam for approximately 30 minutes.
2. Seals and bonding agents must be adequate to withstand fluctuations in pressure in the retort at 121°C (250°F).
3. Materials must meet Federal Food and Drug Regulations.
4. The sealed package must be inherently resistant to bacterial penetration.
5. The package, after the retort process, must preserve its contents at an acceptable quality level for a minimum of 6 months at 37°C (100°F) and two years at 21°C (70°F).
6. The package must fit the pockets of the field clothing.
7. It must be easy to open.
8. It must withstand the hazards of shipment and handling in the military supply system without loss of integrity.

The first two years of the program were devoted to evaluating materials submitted by industry before a material suitable for processing at 121°C (250°F) was found. This was a combination of 75μ (3.0 mils) vinyl, 9μ (0.35 mil) aluminum foil, and 13μ (0.5 mil) polyester with the vinyl as the food contacting surface. Later the vinyl was replaced by a modified polyolefin or high density polyethylene. Up to the present, over 200 materials have been evaluated for the program.

The material evaluation program is a continuing one. In fact, a recently completed re-evaluation of polypropylene as the food contacting surface leads us to the conclusion that polypropylene is equally as acceptable as the modified polyolefin.

The earliest package design consisted of the pouch with a fiberboard backing on one side and the four seals protected by a paperboard picture frame arrangement on the other side. It was realized that the pouch required complete protection against mechanical damage and finally the present paperboard folder type of arrangement was selected. In evaluating its performance it was found that bonding the pouch to the folder provided four times better performance than just placing the pouch in the folder.

Having selected materials and a design which would perform in the retort and also provide mechanical strength it was essential to determine whether the structure was resistant to penetration by bacteria. Studies were made under contract to determine the resistance to bacterial penetration of each of the components of the lamination as well as the complete lamination. Studies showed that each of the components (polyolefin, aluminum foil, and polyester) might be penetrated through pinholes inherent in the materials but that the combination of the three components into a single composite structure effectively overcame this weakness. No penetration of the composite structure was experienced except when a complete break through the three components occurred as the result of deliberate mechanical damage.

Preliminary studies were conducted to determine the type and amount of extractable substances which might migrate from the packaging material into the food during thermoprocessing with favorable results. Approvals for use of the films were received by film suppliers during the period from 1963 to 1966. The extractives question has resurfaced and is currently the primary constraint to progression to test marketing in the United States. Some components of the polyurethane system migrate through the inner ply. These particular moieties, although of low toxicity and migrating in single digit parts per billion quantities, are not, according to the FDA position, covered by existing regulatory clauses. A review of petitions is currently proceeding favorably with approval anticipated in the near future.

Packages containing fruits, meats, and vegetables were stored for periods up to 1 year at 37°C (100°F) and 2 years at 21°C (70°F). The results indicated that the package and the contents were acceptable over this period.

To determine the performance under simulated field conditions, packages were subjected to durability tests at Fort Lee, Virginia. The tests consisted of placing a number of packages in the pockets of troops who traversed an obstacle course as many as 5 times. The results of these tests indicated that the packages were satisfactory for field use.

After a later, full-scale troop test (engineering test-service test) a single problem remained. The shipping, handling, and field testing of the flexible packages when incorporated into a developmental ration - the Meal, Ready-to-Eat, Individual - revealed a failure rate of 0.30% at the point of issue. This finding was based on over 53,000 individual packages examined and tested. This failure rate which is relatively low and included, as a safety precaution, many packages only superficially suspect, was considered too high for a combat ration. Analysis of the defects revealed that inadequate filling and sealing techniques and poor in-plant handling were the causes. Seals were contaminated, irregular, and wrinkled. Pouch body cuts were noted beneath unmarked areas of the overwrap folder. None of the defects or package failures could be attributed to lack of inherent package durability.

It was, consequently, decided rather than an attack on the filling, sealing, and handling problems individually and separately, the most propitious overall approach would be to establish the capability of a complete prototypical production system to reliably manufacture the heat-processed foods in flexible packages. This approach gave credence to recognition that the many production line functions were interrelated and interdependent. Beyond the immediate objective, establishment and use of such a line would yield much valuable data on which to base firm yet realistic procurement documents.

The program was established with the following objectives and guidelines:

<u>Reliability</u>

The reliability goal was the first and most difficult requirement to establish. The three-piece sanitary can was propounded as the criterion, and it is a good one. Tempering scientific knowledge with experience and judgment, as must be done in this instance, a reliability goal of no more than 0.01% defective packages was set. Reliability was defined as the ability of the production line to yield defect free packages (prior to warehousing) when established process control and quality assurance procedures were followed. It is important to note that the 0.01% was a goal and not an absolute requirement.

Equipment

Selection, innovation and/or modification of equipment and components as necessary to achieve the desired reliability. Emphasis would be on filling, sealing, and handling. This could encompass totally new developments.

Diverse Foods

To meet military ration requirements, the system had to be proven for seventeen diverse foods ranging from cake to beef stew. It was assumed that all seventeen could constitute separate filling problems.

In view of low failure rate goal, significant numbers of packages were to be produced. Fifty-thousand (50,000) of each item would be required and would be 100% inspected for defects.

Production Rate

Minimum production rate of 30/minute was specified; higher rates would be acceptable but only if there were no adverse affects on reliability; i.e., no increase in the rate of defective packages.

Inspection

Although not essential at this developmental stage, it was preferred that the line be suitable for operation in a USDA sanctioned and inspected sanitary plant.

Retorting

Standard commercially feasible and acceptable retorting procedures were to be used since our prime objective did not include any innovative retort design or development effort other than modifications to assure uniform and adequate sterility.

This complex program was implemented by a contract to a consortium of food and food engineering companies headed by Swift & Company and including Pillsbury, Continental Can, Rexham (Bartelt) and FMC.

In addition to the hardware development, the program involved establishing test procedures, sampling plans and quality assurance techniques.

The technical effort was divided into two phases. Phase I encompassed paper, laboratory and bench model evaluations and analyses to basically state whether progression to actual engineering, fabrication, and use of a line would be feasible and, if so, to establish the technical and conceptual basis for this confirmatory second phase. Phase I was completed in mid-1970 with the recommendation to proceed to Phase II.

Beyond the simple conclusion that reliability under a production environment was feasible, the effort in Phase I also established that four fillers and four nozzles in combinations could handle all ingredients for the 17 food items under investigation. This permitted a reduction in the scope of the second phase without any adverse effect on attainment of the objective. Consequently, six products representing various particle size and rheological property classes for testing the specified filler-nozzle combinations were selected for the confirming production runs. All other equipment configurations and performance requirements were specified.

The line was developed, tested and the production of the items was completed successfully. The primary measures of performance are the process-oriented failure rates which are shown in Figure #1. The overall post-incubation failure rate of 0.039% compares more than favorably with that of the conventional metal can (with an acknowledged failure rate of 0.1%) and approaches the contract goal of 0.01%. If the gripper cut failures are eliminated, since they are a known, assignable, and correctable cause, the failure rate drops to 0.017%.

This low failure rate becomes even more significant when it is realized that it is an average for six products that could hardly be more diverse in physical characteristics and flexible packaging requirements. Included in the study were relatively low viscosity items with fibers such as pineapple, solid pieces such as beefsteak, a two step operation for beef stew, a semi-solid ham and chicken loaf, a viscous product with suspended particles in fruitcake, and a unique product such as frankfurters.

Furthermore, time and funding constraints within the R&D contract framework necessitated gathering accountable data during periods which under a normal production break-in situation would be considered part of the "learning curve". Although the acceptance test cycles were supplemented by straight runs of 1000 or more, and changes made accordingly, the 50,000 lot production runs had to be initiated before conditions were always proven optimal.

Figure 2 complements the data on failure rates. Besides freedom from defects, the packages and contents had to meet end item requirements in net weight, acceptability, stability (residual gas content) and sterility. With minor exceptions on net weights, these requirements were met.

Figures 1 and 2 present data for six selected representative items prepared under an R&D contract and, therefore, under greater and more sensitive surveillance then normally practiced. Since that time, 16 additional diverse items, each in lesser quantities, have been manufactured on the same line but under conditions closer to a standard production situation without the R&D emphasis on surveillance and data gathering. These are included in the overall listing of items in Figure 9. A 100% inspection of 57,000 of these newer packages (representing all 16 items) revealed only six process-oriented critical defects - an 0.011% failure rate. This is better than the rate experienced with the basic contract and confirms the inherent capability of a properly engineered line, along with the implementation of proper quality assurance methods, to reliably produce Flex Packs.

In summary, relative to the so-called Natick-Swift Project, it has been demonstrated that through judicious formulation of products, proper selection and engineering of equipment, and the application of appropriate and thorough quality assurance measures, the flexible packaging of thermoprocessed foods can be achieved with a degree of reliability at least equal to if not exceeding that accepted for the metal can.

Development Test II

Scope - After development of an item and before its incorporation into military systems, extensive user tests in the final issue form (Development Test II) are carried out to confirm that established requirements have been met, the new item is acceptable *per se*, and, if a predecessor exists, the new item is better than the old one. These tests are carried out by a command that is independent from the developer and involve actual field exercises. In this instance, the Flex-Packs, averaging two per meal, were assembled into meals termed the Meal, Ready-to-Eat, Individual (MRE for short) (Figure 3) and through the auspices of the U.S. Army Infantry Board and U.S. Marine Corps the meals were transported, issued, carried and used by troops on field maneuvers. Foods were heated in and consumed directly from the pouches.

In terms of scope (Figure 4), the tests involved 1,000 men (21,000 meals) in the temperate zone locales of Fort Benning, Georgia; Fort Bragg, North Carolina; and Camp Lejeune, North Carolina. Infantry, armor, airborne, and engineers of the Army and Marines were represented. Arctic tests were carried out with 300 men (5,544 meals) working out of Fort Greeley, Alaska, with sub-test sites at Fort Wainwright and at Sitka. The rations, after assembly in Kansas City, were shipped via commercial air, rail, and motor freight to the two basic test centers. The control item was the current standard - the Meal, Combat, Individual (MCI). From these centers, further transportation and usage tests were run including tracked and wheeled vehicles; sled in the Arctic; air drop with and without parachute; and man-carry.

Results - The results of the user tests (Development Test II) were highly favorable. Basically, the earlier deficiency (1966 tests) related to a high (0.30%) failure rate had been corrected and the MRE was found to be more acceptable than the standard ration. The generalized results, matched to the titles of the major specific requirements, are shown in Figure 5. Comments will be presented on the results related to each requirement, with emphasis finally on transportability and durability, air drop, and acceptability.

Safety------------------------No spoilage of items was encountered; no illnesses attributable to meals. The two main item leakers were considered isolated events.

Personnel Training-------------The briefing and written preparation instructions were adequate. Troops became proficient in the use of the meals.

Food Preparation---------------The "official" method of heating by laying the package over the top of a canteen cup of hot water was adequate; however, other methods including direct immersion in water and direct heating over open flame work well. Preparation could be satisfactorily carried out night or day, singly or in groups, in the temperate or arctic zones.

Camouflage--------------------The camouflage characteristics were equal to the standard item and satisfactory.

Physical Characteristics-------Inspection of meals on receipt showed they were complete and suitable for test. Weight-wise, meals were 3.5 oz (100 gms) over the desired 1 lb/meal; (454 gms/meal); however, a case of MRE's weighed only 19 lb (8.6 kg) as compared to 25 lb (11.35 kg) for the MCI's for at least as much food.
(Not shown in Figure 5)

Human Factors-----------------There were minimal difficulties in preparation, opening, and consumption. Only 3.2% reported any problems in the temperate zone tests while 35% had some difficulty in opening the packages. Pouches were campatible with pockets. A longer spoon was suggested.

Value Engineering-------------There were minor recommendations to reduce the number of packages, primarily related to the accessories.

Three of the requirements areas received greater emphasis in the evaluations than the preceeding list and at least two of these should be of significant interest to non-military technologists and market evaluators.

<u>Transportsbility and Durability</u> - Figure 6 shows the transportation and handling trail for the ration components through the entire test cycle. The main entree items were prepared at Swift & Co's R&D Center, Oak Brook, Illinois, using the prototype line described at previous Joint National Research Council-NLABS and Packaging Institute Symposia on thermoprocessed foods in flexible packages. The Flex-Packs were shipped to the ration assembler in Kansas City via commercial motor freight. During assembly, a 100% inspection was carried out. The completed rations (Figure 6) were packed into solid fiberboard cases (with sleeves) and shipped via three commercial modes - rail, air, and motor freight - to the Arctic Test Center and to the Army Infactry Board facilities at Fort Benning, Georgia. Following another 100% inspection, cases of rstions were allotted to sub-tests which included further transportation, as follows:

---¼-ton military truck over secondary roads (Arctic tests were over distances of 50 miles at each of two temperatures, -19° to -35°F (-28° to -37°C).

---M60A1 tanks cross country (Arctic distances and conditions were the same as those for the ¼-ton trucks).

---Scow type, 200 lb capacity sled (Ahkio) in the arctic for a distance of 5 miles.

---Man-carry for at least 1 mile.

The results showed that the packages held up very well over the total cycle. Figure 7 shows the failure rates (process oriented critical defects or package leakage) at the points of 100% inspection. Of 57,000 pouches inspected at ration assembly, only six, or 0.011%, were considered failures. On receipt at the two test sites, only two Flex-Packs had failed - one side seal leaked; another package had burst on one end with evidence indicating crushing by extreme high weights (such as a fork-lift truck). There were no further reports, written or verbal, or other evidence of failures at time of preparation or consumption.

Aerial Delivery - Emphasis was put on aerial delivery since it was a worse case situation for required performance from the rations. Shocks in the neighborhood of 150-180g's were calculated for some of the free-fall conditions. The requirement stated that aerial delivery should be possible with a 75% recovery criterion if a parachute is not used. With a parachute, no failures were found, even after two weeks' storage.

Without a parachute, the cases were thrown from a low flying aircraft. With single cases, altitude seemed critical in achieving the required recovery rate. When released from 150 feet above ground level, only a 57% recovery rate was noted. When released from 50 feet, the recovery rate rose to 86%.

When four cases were bound with web strapping for free-fall delivery, results were more uniformly favorable. With honeycomb cushioning added, recovery rates were 86% in the temperate zone and 94 to 99% in the arctic. The MCI recovery rate in the arctic with honeycomb ranged from 76 to 94%. Without honeycomb in the temperate zone, recovery was 76%. When one considers the magnitude of abuse the packages experience on free-fall air drop even with honeycomb cushioning, a 75% or higher recovery rate has to be considered high performance.

Acceptability - As shown in a general way in Figure 5 , acceptability was broken down further into four categories.

The first two, quantity and monotony, are not related to features of the Flex-Pack per se, since, at will, one could increase the net weight of each package for satiety or add additional items to help alleviate monotony. For the net weights and menus used in the current tests, the findings were satisfactory. Some soldiers (27 to 36%) could have used more food with the MRE, but the standard MCI evoked the same response. Consumption of the MRE as the sole source of food for seven days resulted in a statistically significant but numerically unimportant decrease in ratings with the final rating being a high 7.39 based on the 1 to 9 hedonic scale (see Figure 8).

Of greater interest to commercial enterprises is palatability. Figure 8 shows, in a very generalized manner, the hedonic ratings for flexibly packaged main entree items, fruits, bakery products. Since items in the MRE did not have adequately similar MCI item to item counterparts, the grouping of ratings was done to present a generalized comparison of the two rations. The MRE meat entree items rated comparatively higher in all instances, especially under arctic conditions. The comparison of fruits is meager, with crushed pineapple the only fruit in the MRE and peaches and mixed fruit in the canned ration. A similar constraint exists for the single bakery product in cans: fruitcake. The test conclusions were that the flexibly packaged items were significantly more palatable than the canned items. Figure 9 is a listing of the main items in the new ration.

The "overall" acceptability rating included such factors as ease of preparation, ease of carrying, palatability, and overall convenience. Perhaps the most significant manifestation of overall acceptance was the free choice exercise where soldiers had free selection of either the MRE or MCI rations. Out of 608 meals, 536 selections were the MRE while only 72 were MCI's.

All characteristics were met. The flexibly packaged ration is more acceptable and suitable than the standard canned ration.

In summary, to meet the world-wide variety of climatic stresses, potential storage and delivery situations, and conditions at point of consumption, while offering high quality ready-to-eat food in a convenient, easy-to-carry package, we feel the retort pouch is the answer.

PACKAGE DEFECTS AFTER INCUBATION

PROCESS ORIENTED CRITICAL DEFECTS

CONTRACT: DAAG 17-69-C-0180 (Swift et al)

Product	Number of Pouches Incubated	Percent Failure by Category				Percent Failure	
		Closure Seal	Gripper Cuts	Stress Riser	Side Seal	Total	Excluding Gripper Cuts**
Pumpable							
Beef Stew	48,738	0.045*	0.002	–	–	0.047	0.045
Pineapple	48,965	–	–	–	0.002	0.002	0.002
Pluggable							
Beefsteak	50,314	0.012	0.060	–	–	0.072	0.012
Franks	50,484	0.008	0.067	–	–	0.075	0.008
Extrudable							
Fruitcake	49,189	0.004	–	0.006	–	0.010	0.010
Ham and chick. loaf	51,281	0.029	–	–	–	0.029	0.029
Total	298,971						
Avg. Outgoing Quality		0.016	0.022	0.001	0.0003	0.0393	0.0173

* Does not include 20 leakers caused by foaming of gravy (on 5 Jan. 73).

** Gripper cuts are a correctable cause of failure.

FIGURE #1

END ITEM CHARACTERISTICS
AVERAGES

CONTRACT: DAAG 17 - 69 - C - 0160 (Swift et al)

Product	Fill Weight: Grams Tolerance: ± 14 gms.			Hedonic Rating	Residual Gas Cubic Cms.	Microorganism Count
	Spec. Avg.	Actual Avg.	Actual Range	1-9 scale Spec >6.0	Specified <10	Specified <10*
Pumpable						
·Beef Stew	142	145	119-167	8.0	5.3	<10
·Pineapple	127	130	121-135	7.6	6.5	<10
Placeable						
·Beefsteak	127	123	114-134	7.5	5.1	<10
·Franks	106	107	98-111	7.7	6.0	<10
Extrudable						
·Fruitcake	135	137	124-147	7.1	not applicable	<10
·Ham and chick. loaf	142	135	124-150	7.2	4.4	<10

* Covers total plate count and putrefactive anaerobes for non-bakery items; molds for bakery items.

FIGURE #2


MEAL, READY-TO-EAT, INDIVIDUAL
Jelly
Jelly
Jelly
Potato Pattie
COCOA BEVERAGE POWDER
COCOA BEVERAGE POWDER
ACCESSORIES
MENU #12

FIGURE 3

DEVELOPMENT TEST II

MAY 1974

MEAL, READY-TO-EAT, INDIVIDUAL

SCOPE

SUBJECTS	SAMPLES	LOCALE	TYPE OF SUBJECT
1,000 MEN	21,000 MEALS	FORT BENNING, GEORGIA	INFANTRY
		FORT BRAGG, NORTH CAROLINA	ARMOR
		CAMP LEJEUNE, NORTH CAROLINA	AIRBORNE
			ENGINEERS
			MAINTENANCE
			MARINES
300 MEN	5,544 MEALS	FORT GREELEY, ALASKA	INFANTRY
		FORT WAINWRIGHT, ALASKA	AIRBORNE
		SITKA, ALASKA	

CONTROL: STANDARD MEAL, COMBAT, INDIVIDUAL: 7,000 TEMPERATE CLIMATE
1,800 ARCTIC CLIMATE

FIGURE 4

DEVELOPMENT TEST II

MAY 1974

MEAL, READY-TO-EAT INDIVIDUAL

(CONTROL: MEAL, COMBAT, INDIVIDUAL)

GENERALIZED RESULTS

SAFETY	-	NO EVIDENCE OF HAZARD
PERSONNEL TRAINING	-	PREPARATION INSTRUCTIONS WERE ADEQUATE
AERIAL DELIVERY	-	WITH PARACHUTE, 100% RECOVERY
	-	WITHOUT PARACHUTE, 75% RECOVERY
FOOD PREPARATION	-	NO DIFFICULTY
FOOD ACCEPTABILITY	-	QUANTITY - ADEQUATE
	-	MONOTONY - NO (1 WEEK TEST PERIOD)
	-	PALATABILITY - HIGH
	-	OVERALL - BETTER THAN STANDARD
CAMOUFLAGE	-	GOOD
TRANSPORTABILITY AND	-	SUITABLE FOR ALL MODES OF TRANSPORTATION, INCLUDING MAN-CARRY
DURABILITY	-	FOUR DEFECTS IN 188,000 PACKAGES

FIGURE 5

TRANSPORTATION AND HANDLING TRAIL
DEVELOPMENT TEST II, MEAL, READY-TO-EAT

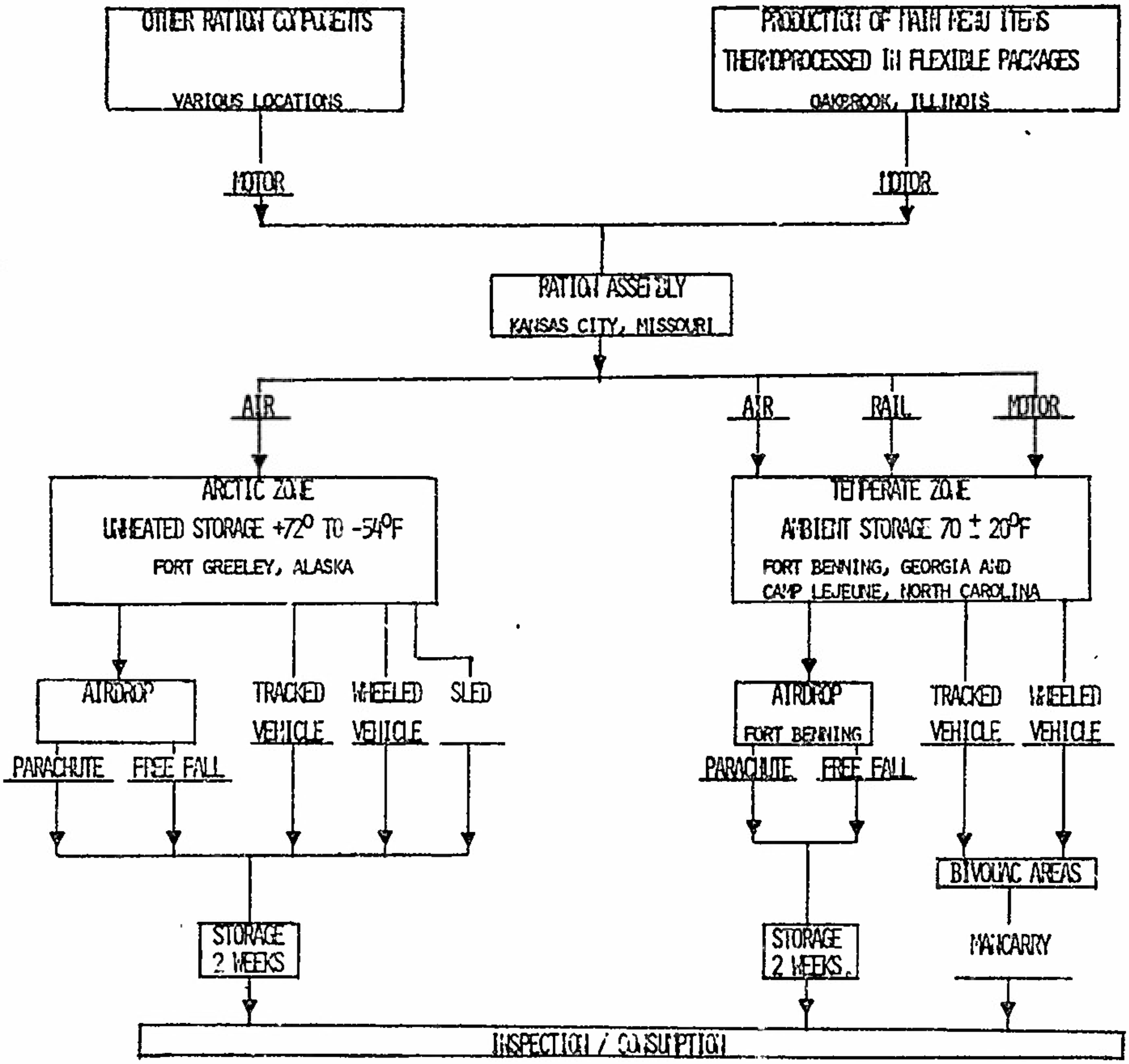

FIGURE #6

DURABILITY OF THERMOPROCESSED FOODS IN FLEXIBLE PACKAGES *

100% INSPECTION SITE	NUMBER EXAMINED	PERCENT FAILURES
RATION ASSEMBLY	57,000	0.011%
FIELD TEST SITE	54,000 APPROX.	0.004%
— FT. GREELEY, ALASKA		
— FT. BENNING, GEORGIA		
— CAMP LEJEUNE, N.C.		
CONSUMPTION	30,000 APPROX.	0**

° DOES NOT INCLUDE AIR DROP TESTS

°° DEVELOPMENT TEST II, MEAL-READY-TO-EAT

FIGURE 7

GENERALIZED ACCEPTANCE OF THERMOPROCESSED ITEMS
DEVELOPMENT TEST II MEAL, READY-TO-EAT

	MEAL, READY-TO-EAT (FLEXIBLE PACKAGES)					MEAL, COMBAT, IND. (CANS)				
	NO. OF ITEMS	TEMPERATE		ARCTIC		NO. OF ITEMS	TEMPERATE		ARCTIC	
		HOT	COLD	HOT	COLD		HOT	COLD	HOT	COLD
MEAT ENTREE ITEMS	12	7.8	7.5	7.7	7.1	11	7.0	6.3	5.9	5.6
FRUITS	1	N/A	7.3	N/A	7.4	2	N/A	7.8	N/A	—
BAKERY PRODUCTS	7	N/A	7.2	N/A	7.2	1	N/A	5.2	N/A	—

RATING SCALE -

9 - LIKE EXTREMELY
8 - LIKE VERY MUCH
7 - LIKE MODERATELY
6 - LIKE SLIGHTLY
5 - NEITHER LIKE NOR DISLIKE
4 - DISLIKE SLIGHTLY
3 - DISLIKE MODERATELY
2 - DISLIKE VERY MUCH
1 - DISLIKE EXTREMELY

FIGURE #8

FLEX-PACK PRODUCTS PACKED ON PROTOTYPE PRODUCTION LINE AT SWIFT & CO.

EXTRUDABLE (Creamery Package Stuffer Filler)

- Fruitcake
- Cherry nut cake
- Maple nut cake
- Chocolate nut cake
- Orange nut cake
- Pineapple nut cake
- Spice cake

EXTRUDABLE (Bartelt Model D Filler)

- Ham and chicken Loaf
- Chicken Loaf
- Beef Loaf

FIGURE #9

PUMPABLE (Bock Piston Filler)

- Beans in tomato sauce
- Chicken ala King
- Ground Beef with Pickle Flavored Sauce
- Pineapple in Syrup

PLACEABLE (Rotary Turret Filler)

- Beefsteak
- Frankfurters
- Ham Slices

DUAL (Pumpable and Placeable)

- Beef Stew
- Beef (diced) and Gravy
- Beef slices in barbeque sauce
- Meat balls in barbeque sauce
- Turkey (diced) and Gravy

FIGURE #9 (CONT'D)

Engineered Foods in the Food Supplies of Tomorrow

by Marcus Karel

Presented at:

Foods for the Armed Forces

Third International Meeting

14-17 October 1975

U.S. Army Natick Development Center

Natick, MA

Engineered foods are important in the present food supply and will become even more important in the future. The term implies food systems designed and fabricated from components, either synthetic or natural, in order to achieve specific nutritional, organoleptic stability or economic advantages. In my presentation I would like to concentrate on three aspects of development of engineered foods:

1. Reasons for development of engineered foods.
2. Present status and expected developments in marketing of engineered foods.
3. Research needs in the area of engineered foods.

1. Reasons for development of engineered foods

In the developed countries, and in a number of the more rapidly advancing developing countries there are certain common societal pressures for changes in the traditional modes of food production and consumption.

a) Pressure to reduce labor

One of the most significant features of economies of developed countries is the trend to decrease demand for manual labor in production, preparation, and alas, even consumption of foods. These pressures have led to development of prepared foods, to increased consumption of snacks rather than home-cooked meals, and to a tremendous increase in the food service establishment. The rise of fast service restaurants has become world-wide, and the sight of "golden domes" of a fast service chain is now an established feature of the Champs Elysees. In a recent article in the New York Times, Tom Wicker bemoaned the rise of fast service hamburger consumption at the expense of smorgasbord in Sweden. By 1980 perhaps as much as 50% of food consumed in the United States may be served by Cafeterias, quick service restaurants and other food service operations.

b) Concern for environment

At the same time the public opinion is demanding maximum efforts toward conservation of the environment. These demands find legal expression in regulations of the EPA.

c) Concern for nutrition and safety of foods

These concerns are translated in governmental regulations and play a very significant role in affecting the way foods are produced, processed and marketed. Production, for instance is affected by regulations of OSHA, which are designed to maximize safety of workers in manufacturing establishments. Production, processing distribution and marketing are strongly affected by public desire to eliminate any potentially harmful additives. Finally, recent emphasis on nutritional quality places new requirements for control and labelling of nutrient content.

d) Concern for availability of resources

The awareness that our resources are severly limited is very new to our public opinion, even though the limitations have always been there. The limitations of resources have become particularly apparent recently, because the increasing population pressure has been further amplified by trends in several blocks of countries to adapt the patterns of consumptions hitherto prevalent primarily to Western Europe, North America and Oceania. This trend consists of conversion of large proportion of the grain supply into animal tissue including meats, eggs and milk, and has caused an increased pressure on grain supplies.

At the very same time, the oil embargo of 1973 and the subsequent increases in the price of crude oil have assured that the American approach to increased agricultural productivity, which resulted in an increase in the yield of corn by a factor of 2.4 from 1945 to 1970, will not be feasible in the future. The reason for it is that this increase in yield was bought at the expense of lavish expenditure of energy, primarily in the form of fertilizer, and mechanization. The energy cost of growing corn has increased from 1945 to 1970 by a factor of 3.1. If one considers the additional multiplier for the constant dollar cost of oil in 1975 compared to 1945, it is evident that the cost of increasing yield is becoming very expensive indeed, and may be unattainable in some parts of the world.

The concept of engineered foods does allow the utilization of components to achieve aims which provide answers to some of the above societal pressures. Engineered foods provide first of all flexibility. By utilizing a variety of essentially equivalent components for the same purpose it is possible to bridge periods of shortage of specific raw materials. For instance the protein present in milk is always the same and obtainable only as secretion from lactating animals. Engineered high protein beverages such as milk analogues could utilize properly processed proteins from oilseeds, grains, yeast or even milk protein, extracted, processed and stored during years of plenty to provide a reserve for years of shortages.

Engineered foods also meet the requirement for nutrition and safety. They provide a basis for formulation of nutritionally balanced meals for specific population groups. They may in fact provide a potential for medication through the food supply.

This last concept may be controversial, but it is entirely possible that it may represent less of an intrusion on individual liberties than some current practices. It may be possible, for instance, to incorporate fluoride or phosphate compounds in cookies or in chewing gum, to reduce caries development in children, and thus reduce the need to fluoridate water which is consumed in part by older population groups for whom fluoride is less beneficial.

Foods designed for space flights were in fact compounded on the basis of high palatability, therapeutic potential (for instance supplementation with potassium), nutritional balance and maximum stability characteristics.

Engineered foods may be useful in controlling, or ameliorating the effects of several nutrition-related diseases including diabetes, high blood pressure, hypercholesteremia, acne, caries, obesity and possibly others.

2. Present status and prospects for engineered foods

Engineered foods are not new. Bread and other baked items, cheese, margarine, sausages and many other ancient food concepts fall into the category of engineered foods. Even the more recent concept of utilization of synthetic components and of building-in controlled nutritional characteristics is by now a well established industrial reality. One need only mention concepts such as Metrecal, Tang, and the large number of instant breakfast mixes which are available in the marketplace. At the present time the most commonly used approaches are based on textured vegetable proteins. Among very successful concepts in this area are the "Morningstar Farms" breakfast foods and various meat extenders. Another commonly used concept is the shaping of meat chunks and pieces into larger and more easily marketed shapes such as simulated "roasts", "steaks", etc.

A recent survey conducted in the U.S.A. by Frost and Sullivan and published in Food Technology in December of 1973, projects a total market for fabricated foods increasing to 23 billion dollars by 1980 from the 12 billion dollar estimated for 1972. The biggest increases in the market size were projected for vegetable protein products, which are expected to reach sales of 1.5 billion dollars compared to the 1972 level of 80 million. A similar Delphi-type forecast published by the British Proceedings of the Royal Society surveyed the opinions of experts as to the expected availability of non-conventional raw materials for fabricated foods. Most rapid advances were expected in carbohydrates from cellulose, and in utilization of proteins from plant materials. Single cell protein and synthetic materials for direct human consumption were considered less likely to be utilized by the food industry within the present century.

3. Major research needs

The future development of engineered foods will require major research advances in the material science of foods. In general, the more unconventional the technological need, the longer will be the lead time required to develop and implement that technology. This relationship between degree of innovation and time lag in implementation is being reinforced by legislative requirements to prove the safety of any unconventional food process of food material. An essential element is the need for new materials. The discipline of materials science in food technology and food engineering needs substantial expansion. The principles of food engineering cannot be effectively applied without systematic quantification of the nature and function of food materials. Resources with which to gather these data are limited and time is running short.

The chemical industry developed its present state of advanced technology by characterizing the physical and physico-chemical properties of the materials being processed and by designing engineering processes on this basis. In contrast, the food industry has developed on a traditional basis in which skilled artisans relied on qualitative and subjective procedures passed from generation to generation. In the future such methods will not be adequate to meet food supply needs. The modernization of the food industry (which is essential to provide needed increases in productivty) will require a systematic and in depth study of food materials properties.

Food materials are complex and have many attributes related to organoleptic quality which are difficult to correlate with standard engineering properties. Mechanical properties of foods are only one example of complex properties which determine organoleptic quality, in this case the texture. Research is needed in order to investigate and develop methodology for measurement and characterization of chemical, physical and functional properties of food materials, and their role in determining the overall quality, processing suitability and shelf stability of foods.

Another problem is the complex heterogeneous morphology of foods. Even a droplet of spray dried milk which was prepared from "homogenized" milk develops a new and complex heterogeneity. There is need to research a basis for formation of such internal morphology to utilize it to produce foods with controlled properties.

Research is also needed on microstructure on natural and fabricated food materials as related to evaluation of functional properties and processing effects. This research should include such areas as microstructure of emulsions, and of such finished products as bread and texturized foods. A goal of this research should be to relate the microstructure to mechanisms of interaction within foods. New structure-forming materials need to be introduced to development. For instance polysaccharides are still underexplored compared to proteins. By controlled diffusion of crosslinking agent (Ca^{++}) into alginate solutions it is possible to control internal heterogeneous structure. Some work of this is presently conducted in Russia, and has led to patented inventions for various food systems ranging from macaroni to synthetic caviar. Another approach suggested by Michaels at Dynapol is crosslinking of food additives to larger molecules (immobilized additives similar to immobilized enzymes) to prevent absorption in the body and thus avoiding problems of toxicity and undesirable side reactions.

A beginning has been made in developing the research projects needed to establish material science of foods. Since I am most familiar with research at M.I.T. I shall present some examples of research projects currently underway at that institution. Similar projects are of course being carried out at various other research institutes.

Table 1 shows some selected projects in the area of "material science of foods." The emphasis in this research is on correlating physical properties such as dielectric constant, diffusion coefficients and mechanical properties with composition of foods, and to utilize the quantitative knowledge of physical properties in process design.

Research topics in "development of non-conventional foods" are shown in Table 2. The emphasis is in two areas: intermediate moisture foods and non-conventional protein sources. In the latter area considerable research is devoted to modification of acceptability and wholesomeness of single cell proteins. If single cell proteins are to become an important food component research breakthroughs in these areas will have to be achieved and applied on an industrial scale.

Table 3 lists topics in "egineered foods". In this table are presented projects related to actual creation of food structures from unusual components and the determination of processing and stability characteristics of such engineered foods.

An important aspect of technolgoy of all foods, but especially that of engineered foods is storage stability and packaging. Table 4 lists several research projects in this area. One of these devoted to computer-aided simulation of behavior of foods in storage and processing is being carried out with a grant from the U.S. Army Natick Laboratories, and is aimed at developing a rational quantitative approach to prediction of storage stability to calculation of packaging requirements and to optimization of food processes.

The examples given above represent some of the research needs and some approaches to their fulfilment. Much more must be done, and at a more rapid pace if abundant, nutritious, safe and reasonably priced food supplies are to be available in the future.

Table 1 — Material Science of Foods

Dielectric properties of food components.
Water binding by foods.
Structure of dehydrated foods.
Diffusion of water and of flavors in foods.
Texture and rheological properties.
Gelation in food systems.
Microscopic techniques for characterization of food microstructure.

Table 2 — Development of Non-Conventional Foods

Principles of formulation of intermediate moisture foods.
Single cell protein from yeast grown on methanol.
Survey of potential protein resources of the United States.
Modification of single cell protein by enzymatic processes.
Reduction of nucleic acid content of single cell proteins.

Table 3 — Engineered Foods

Fruit simulating structures based on alginate gels.
Plastein reaction and development of engineered foods.
Nutrient distribution and retention in formulated foods.
Squid proteins as raw material.
Spinning and extrusion of single cell proteins.

Table 4 — Food Stability and Storage

Computer-aided simulation of food behavior in storage.
Computer-aided simulation of nutrient losses in processing.
Relations between diffusional and surface properties and oxidation of foods.
Flavor retention and structural collapse in dehydrated foods.

SESSION III -- OPERATIONAL & GARRISON (CANTEEN) FEEDING

Chairman: Colonel Norman D. Heidelbaugh, USAF, VC
Headquarters, US Air Force
Washington, DC

Recent Developments in the US Army Food Irradiation Program	Dr. Edward S. Josephson and Dr. Howard C. Johnson U.S.A.
Activities on Food Research and Product Development for the National Defence Research Organization of the Netherlands	Dr. E. W. Hellendoorn The Netherlands
The Feeding of The British Army in 1975	Major N. S. Nash U.K.
More Technology in Time of Crisis	Dr. K. G. Arnestad Norway
Customer Morale & Behavioral Effectiveness; Accomplishments & Goals of Psychological Studies of Food Service Systems	Dr. H. L. Jacobs and Dr. H. L. Meiselman U.S.A.

RECENT DEVELOPMENTS IN THE U. S. ARMY FOOD IRRADIATION PROGRAM

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"Foods for the Armed Forces"
14-17 October 1975

Recent Developments in the U. S. Army Food Irradiation Program

by

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INTRODUCTION

Mr. Chairman, ladies and gentlemen, I am honored to be invited to speak at this Third International Meeting on "Foods for the Armed Forces" on Recent Developments in the U. S. Army's Food Irradiation Program. I shall attempt to give you an overview on this topic, including current activities, present status, problem areas, and future plans.

Since 1953 the Army has carried out research on irradiation sterilized foods to reduce the burden of refrigeration while providing its personnel with shelf-stable foods which are highly nutritious, organoleptically acceptable and have the taste characteristics of fresh food. Early in the program it became apparent that prepackaged meats, poultry, fin fish and shellfish could be subjected to the high irradiation doses required for sterility and still retain good organoleptic quality. This program, which began at the Quartermaster Food and Container Institute for the Armed Forces in Chicago, Illinois, was moved to the Natick Development Center, Natick, Massachusetts in 1962. In 1970 the Secretary of the Army, recognizing the broad implications for the nutritional, environmental, and economic well-being of our society as a whole, specified that the Army's effort should encompass civilian as well as military considerations.

Since 1960 the U. S. Energy Research and Development Administration (ERDA) and its predecessor, the U. S. Atomic Energy Commission (AEC), have sponsored most of the research using substerilizing doses of ionizing radiation for food preservation. Food irradiation has been part of the President's "Atoms for Peace" Program since its inception in 1953 and part of the Department of Defense's Food Research, Development, Test, and Engineering Program since 1972. From the earliest days, the Army Medical Department has been responsible for establishing the safety for consumption ("wholesomeness") of irradiation sterilized foods.

APPLICATIONS TO FOOD PRESERVATION

Some of the more promising applications of ionizing radiation to the treatment of food are shown in table I (1, 2). At the highest irradiation doses, all food spoilage organisms and pathogens transmitted by food are killed (radappertization); prepackaged meats, poultry, and seafood can keep for years without refrigeration and on the plate of the consumer will still have a degree of acceptance approximating that of fresh food freshly cooked. At the lowest irradiation doses, certain physiological functions associated with sprouting in tubers such as white potatoes and in bulbs such as onions will be disrupted; these foods will not spoil during post harvest storage for as long as 1 year because of sprouting. Exposure of fruits such as tomatoes, bananas, mangoes, and papayas to intermediate doses of ionizing radiation will slow down ripening, and give these foods an extended shelf life ranging from a few days to several weeks. One application not included in table I is the use of irradiation to shorten rehydration and cooking time of dehydrated vegetables. For example, with diced potatoes an irradiation dose of 8 megarads can shorten cooking time from approximately 20 minutes to less than 4 minutes.

ADVANTAGES

The irradiation process is attractive because there is only a slight temperature rise in the foods during the course of the treatment. It is considered a "cold process." The irradiated foods undergo minimal changes in texture, flavor, odor, and color so that on the plate of the consumer the irradiation-preserved food is almost indistinguishable from fresh food freshly prepared. The advantage of this process is that we can put fresh-like food on the plate of the consumer on land, at sea, under the waters, in the air, and in outer space.

Another advantage of the process is its flexibility; that is, the process can be used to preserve a wide variety of foods in a range of sizes and shapes ranging from crates of potatoes to prepackaged flour in 50- or 100-pound sacks, to large roasts (beef, lamb, pork), turkeys, and hams, to sandwiches of sliced meat, fish, and chicken. The variety and dimensions of products that can be preserved by ionizing radiation fit in very well with present and anticipated future processing methods of the food industry. Astronauts and personnel at the bottom of the sea can have their meals and snacks in ready-to-eat form, in the form of slices or sandwiches, or as warm-and-serve or cook-and-serve items. Foods processed by ionizing radiation are compatible with the trend for greater convenience, simplicity in preparation, and reduction of labor in the kitchen. The shelf-life extensions without refrigeration are measured in days or weeks for certain fruits and vegetables and are from 3 to 5 years and possibly even longer in the case of meat, poultry, fin fish, and shellfish.

The Army's program is periodically reviewed by the Committees of the U. S. Congress having legislative and fiscal overview, particularly the Joint Committee on Atomic Energy. The great interest, encouragement, and support by this important Committee have been vital to the success of the Army's program.

Since 1956 the activities of the Federal Agencies concerned with the total national effort in irradiation preservation of foods have been coordinated by participation of each agency, including the Army, in the Interdepartmental Committee on Radiation Preservation of Food chaired by the U. S. Department of Commerce. This Interdepartmental Committee will play an important role in encouraging commercialization of the food irradiation process after FDA and USDA give legal approvals.

More than 50 countries have programs on food irradiation. Most of these countries are members of the United Nation's International Atomic Energy Agency (IAEA) and the Food and Agriculture Organization (FAO). Except for the high dose food irradiation research conducted by the U. S. Army, most of the food irradiation research world-wide is on low dose irradiation of agricultural commodities.

During the past year the Secretary of the Army directed that the schedule for the wholesomeness portion of the program be accelerated. The reason for this acceleration is to provide as soon as possible the data required by FDA and USDA to reach decisions on granting legal approvals for irradiation sterilized beef, chicken, pork and ham. When these approvals are received, it is expected that the meat processing industry will have a broad enough spectrum of foods and a military and civilian consumer market to be encouraged to produce these foods on a commercial scale.

RADIATION SOURCES

The three basic types of ionizing radiation used for processing of foods are gamma rays from cobalt-60 and cesium-137, electrons having a maximum energy of 10 million electron volts (MeV) (5 MeV in the United Kingdom) and X-rays (5 MeV maximum energy) produced by electrons in an X-ray target. The gamma rays, electrons and X-rays cause temporary ionizations and excitations of the molecules in the food. The ionized and excited molecules, together with unstable secondary products, inactivate the organisms (yeasts, molds, bacteria, insects, parasites, viruses) of spoilage or public health significance in the food. In the case of some fruits and vegetables another effect of exposure to irradiation is to slow down post harvest growth and maturation (ripening).

With ionizing radiation we can provide foods high in nutritive value and foods high in morale value. We can provide better quality food than hitherto possible. The food can be disease free, that is, free of all pathogens associated with food-borne diseases. We can provide a larger variety of foods such as fresh fruits and shelf-stable meats and poultry which have the character of fresh food. Because the food can be prepackaged and precooked at one place prior to irradiation, the cost in money, time, and labor for food handling all the way to the ultimate consumer can be reduced. Further reductions in cost result from reducing requirements for refrigeration and refrigeration maintenance. Spoilage losses from insect infestation, sprouting, or refrigeration breakdown will be minimized. By providing a broader spectrum of foods through introduction of irradiated items, discord from food monotony, particularly during long voyages, will be reduced.

LEGAL ASPECTS

Ionizing radiation is the first entirely new method used to preserve food since Nicholas Appert discovered thermal canning in 1809. The irradiation process is the first major food-preservation method to appear since food regulatory agencies were established at the national level in many countries.

In the United States, the food regulatory agency most directly involved is the Food and Drug Administration (FDA). In the case of meats and poultry, the Department of Agriculture (USDA) also has legal responsibility.

There are several statutes which control the use of ionizing radiation for food processing. Among the laws are the Food, Drug, and Cosmetic Act as amended in 1958. Under this law ionizing radiation is legally defined as a food additive. The Federal Meat Inspection Act and the Poultry Products Inspection Act have been on the books for a long time. In recent years, with the great interest in consumer affairs, we have seen passage in 1966 of the Fair Packaging and Labeling Act; in 1967, of the Wholesome Meat Act; and, in 1968, of the Wholesome Poultry Act.

The impact of the Food, Drug, and Cosmetic Act of 1958 is to outlaw all new food additives, including ionizing radiation, from commercial application. The law provides for exemption from this universal ban by petitioning the FDA for approval of new food additives. For food preservation by ionizing radiation, FDA's approval is required for each food processed in this fashion. The law also requires approval by FDA of packaging materials in contact with food during radiation processing.

STATUS

The scientific feasibility of using ionizing radiations to preserve highly perishable animal protein foods, such as meat and poultry, for long periods of time under non-refrigerated conditions has been proven under the U. S. Army Radiation Preservation of Food Program. Technology is well advanced for radappertized ham, bacon, pork, pork sausage, beef, corned beef, chicken, codfish cakes and shrimp and, except for the determination of the irradiation dose requirements, for lamb, turkey, and ground beef with binders (3, 4).

The radappertization process basically involves preirradiation treatment with heat (65 - 75°C) to inactivate autolytic enzymes; packaging under partial vacuum in a sealed container impermeable to moisture, air, light, and micro-organisms; bringing the food package to the temperature at which it will be irradiated; and, exposing the food package to ionizing radiation until the absorbed dose is obtained.

Table II summarizes some of the major technological parameters of radappertized foods which have been successfully produced in the laboratory. Bacon irradiated at temperatures below 25°C is of excellent quality. Other products develop off-flavors that are greatly reduced by irradiation at low temperatures. Low temperature irradiation is a basic requirement for producing acceptable beef (4). Other foods can be improved by irradiating them while frozen at -30° + 10°C (5). However, as temperature is lowered below 0°C, higher irradiation doses are required to achieve the same degree of biocidal effect. Also the cost of chilling increases as temperature is lowered below the limit of mechanical refrigeration which is about -30°C. Therefore, the most favorable balance of quality, cost, and required irradiation dose appears to be at about -30 ± 10°C.

The minimum radiation doses (MRD) given in Table II were obtained in accordance with the 12D concept of microbiological safety. The MRD data indicate the radiation dose in megarads needed to reduce the numbers of viable spores by a factor of 1×10^{12}, based upon the recovery data of the most radiation resistant strains of Clostridium botulinum used in inoculated pack studies with the individual foods in sealed cans as the substrate (6). As the data indicate, the MRD values depend on the food and its temperature during irradiation. The foods containing curing agents have lower MRD's (ham, pork sausage, bacon) than foods without these ingredients.

Mixtures of about 0.75 percent sodium chloride and 0.25 to 0.5 percent food grade phosphates, such as sodium tripolyphosphate (TPP), are excellent binding agents both for radappertized hamburgers (ground beef) and for formed rolls of beef, chicken, pork, and lamb. Weight loss during enzyme inactivation was reduced from the normal 30 - 35 percent loss with no additives to 10 - 15 percent with these additives (7). This improved their juiciness. All products retained their shape through extended room temperature storage and during kitchen preparation. The meat rolls may be readily sliced after reheating. In addition, as shown in Table II, the MRD for beef was reduced from 4.7 to 3.7 Mrad when 0.75% NaCl and 0.375% TPP were added to the beef prior to enzyme inactivation and irradiation.

To protect the radappertized foods from bacterial recontamination after irradiation and long term non-refrigerated storage, durable packaging of the food prior to irradiation is required. Two program goals have guided progress in the field: (a) determining reliability of commercially available metal containers for low temperature radiation sterilization of prepackaged foods, and (b) developing flexible lightweight containers capable of withstanding rough handling and storage, retaining protective qualities during storage without any adverse effects on the food contained therein. There is no problem in irradiation of tinplate containers at doses up to 7.5 megarads at temperatures as low as -90°C, provided the can enamels used are of the epoxyphenolic or phenolic types and the end-sealing compounds are the blend of cured and uncured butyl elastomers, the blend of polychloroprene and butadiene-styrene elastomers, or blend of polychloroprene and uncured butyl elastomers (8).

The U. S. Food and Drug Administration approved four plastic films as food contactants for radappertized foods: polyethylene, polyethylene terephthalate, vinyl chloride vinyl acetate copolymer, and nylon 6. Other films being investigated for FDA approval are the ethylene-butene copolymer, vinylidene chloride-vinyl chloride copolymer, polystyrene, plasticized polyvinyl chloride, nylon 11, and a blend of ethylene-butene copolymer and polyisobutylene. These films are used as the food contactant layer in a laminated structure with aluminum foil (middle layer) as a moisture and oxygen barrier, and either polyethylene terephthalate or nylon 6 as the outside layer to give strength to the laminate in the form of pouches. The laminated flexible package consisting of chemically bonded polyethylene terephthalate and medium density polyethylene as the food contactant, aluminum foil (middle layer) and nylon 6 (outside layer) was found to be very reliable for packaging irradiated foods (8). Over 400,000 such flexible packages were used during 1972 - 1974 for vacuum packaging of more than 40,000 kg. of beef for experiments to prove safety for consumption of radappertized beef with less than 0.01% failures after vacuum packaging and electron irradiation at -40 to -5°C between 4.7 and 7.1 Mrad. Both metal containers and flexible packages have to be sealed under vacuum to prevent rancidity of the lipids in the foods packaged for radappertization.

Table III shows quality of radappertized hams using the 9-point hedonic scale for preference (9). In the case of meat and poultry products, the rating of 5 ("neither like nor dislike") is considered to be the threshold of acceptability. A rating of 7 or above indicates a highly acceptable product.

It is of more than passing interest that the ham from the Experiment No. 72/80 in Table III was used at the request of the National Aeronautics and Space Administration (NASA) by the astronauts of the Apollo 17 flight to the moon in December 1972. The ham slices, 12 mm in thickness and weighing approximately 105 + 5 g, were eaten at three meals in sandwiches made with radurized bread (50,000 rads) using radiation insect-disinfested rye flour (50,000 rads). The verdict of the astronauts was most encouraging. They reported:

> *The juicy, chewy [irradiated] ham and cheese on [irradiated] rye was one of the space culinary delights enjoyed by the Apollo 17 astronauts* (10).

Radappertized ham slices were also orbited in Skylab III as emergency back-up food.

In the Apollo-Soyuz Test Program (ASTP), the Natick Development Center provided the radappertized ham, corned beef, turkey slices, and beef steaks which were eaten in flight by the American astronauts. One of the Russian cosmonauts, who likes his steak rare, ate the radappertized beef. How did the astronauts and cosmonauts enjoy the radappertized foods? I quote from a 9 October 1975 letter from the National Aeronautics and Space Administration:

> *In general the Apollo-Soyuz crew was very satisfied with the quality and the quantity of food available during the flight. The appetites of the crew members in flight were reported to be the same as during the pre-flight period.*
>
> *The crew was particularly pleased with the "Natick Foods," as they refer to the irradiated and thermostabilized meat items in flexible foil laminated packages. They were pleased with the flavor, texture, and convenience of these products.*
>
> *The following irradiated products were used in the ASTP menus:*

Beef Steak, Charcoal Broiled	*Corned Beef*
Ham	*Turkey*
Rye Bread	*Breakfast Rolls*

Since there was no heating capability on the Apollo vehicle, all products were eaten at cabin environmental temperature.

Frozen sandwiches were prepared pre-flight for the crew to carry in their suit pockets at the time of launch. The sandwiches were made of irradiated rye bread, margarine, and the irradiated meats (ham, corned beef, and turkey) supplied by Natick.

Thank you for your contribution and efforts which helped make the Apollo-Soyuz food system successful and satisfying to the crews.

Data in Table IV show good acceptance by test panels of radappertized shrimp, pork sausage and beef. Similar data were obtained on other foods radappertized in the frozen state (4, 11).

In the United Kingdom, considerable experience is available on animal feeds irradiated at 2.5 Mrad for pathogen-free feeds and at 5.0 Mrad for germ-free feeds (1, 2). Irradiated feeds are more nutritious than thermally sterilized feeds. Thermal sterilization (autoclaving) lowers considerably the concentration of individual amino acids, particularly the essential amino acids, lysine, methionine and tryptophan. This was shown by animal feeding studies with rats and mice using thermally sterilized versus irradiation sterilized animal feeding mixtures (12).

Massa (13) reported that irradiation of hoof and mouth disease virus in the dry state with a 4 Mrad dose reduced the number of virus particles by 10^7; the same degree of reduction in the liquid state was achieved by 3 Mrad. Radappertization at cryogenic temperatures in sealed containers in the absence of oxygen offers a means of eliminating this virus in many infected animal products.

In 1969 the Health Authorities of the United Kingdom and the Netherlands approved radappertized foods for hospital patients in reversed barrier isolation. No nutritional or toxicological problems have been reported as a consequence, even though patients subsist entirely on these foods for several months. These patients have either received organ transplants or are being treated for leukemia. Their immune responses to materials foreign to their bodies have been suppressed to minimize rejection. Because the suppression of the immune response makes the patients hypersusceptible to bacterial infections, they are kept in a sterile environment and are fed sterile diets.

Although heat can sterilize diets, it is not a suitable method for all foods and limits the variety of foods the patients can eat. Radappertization permits a much wider selection of foods and helps stimulate the patient's appetite with improvement in morale and nutritional condition.

In 1965 the U. S. Army Natick Development Center, the U. S. Atomic Energy Commission, and Atomic Energy of Canada, Ltd., began a joint research program using substerilizing doses for radurization (reduction in total numbers of organisms in food to extend shelf life) and radicidation (elimination of all pathogens in food except spore-forming anaerobes and some viruses) of chilled and frozen chicken. Technology and proof of safety to the consumer having been well established, in 1973 the Food and Drug Directorate of the Canadian Department of National Health and Welfare gave permission for test marketing of chicken radicidized (700 Krad maximum) to control salmonellae (14).

NUTRITIONAL ASPECTS

The effect of ionizing radiation on the nutritional value of foods is not markedly different in degree from that of other methods of preservation. Protection of nutrients is improved by holding the food at low temperature during irradiation and reducing or excluding free oxygen from the radiation milieu. Data in Table V indicate that retention of thiamine, riboflavin, niacin, and pyridoxine in ham radappertized at cryogenic temperature is as good as, or better than, the retention of these vitamins in the same ham thermally sterilized under time and temperature conditions used commercially.

The great body of evidence accumulated during the past two decades, with few exceptions, indicates that irradiated foods are as nutritious as thermally processed foods (15). Raica and Howie (16) reported no changes in digestibility of proteins, fats, and carbohydrates exposed to doses of 5.6 Mrad. Read et al (17) found no differences in metabolizable energy and available protein, fat, and carbohydrate between radappertized (5.6 Mrad) and nonirradiated control composite diets fed to rats for 4 generations. Kennedy (18) observed little change in nutritive value of animal feeds (protein concentrate) using doses of 0.5 and 1.0 Mrad and no nutritional changes with frozen eggs irradiated at 0.5 and 5.0 Mrad. Ley (19) found no adverse effect on the nutritive value of animal feeds irradiated at 0.1 and 0.5 Mrad. He concluded that radiation at 2.0 Mrad is superior to heat processing with respect to retention of protein quality. He also described excellent results with radappertized feed for germ-free rat and mouse colonies maintained for 5 years. Radappertization and radicidation have been used in preference to thermal sterilization to sustain germ-free and specific pathogen-free rats, mice, pigs, and chickens (20, 21, 22, 23, 24).

A comprehensive review of the effects of ionizing radiation on nutrients has been written by Josephson et al (25).

REDUCED DEPENDENCE ON CHEMICAL FOOD ADDITIVES

Recently the Army Natick Development Center researchers investigated the possibility of reduction in the additions of nitrite and nitrate in cured meats, such as ham and bacon. Nitrite and nitrate impart the organoleptic qualities associated with the characteristic flavor and pink color of cured meats. Nitrite, in combination with other curing agents, also inhibits toxin production by Cl. botulinum in thermally processed meats. The use of these curing agents, however, has been under reappraisal by the meat industry and health regulatory agencies because under certain conditions nitrite may react with free amines in food forming nitrosamines, which are carcinogenic (26, 27, 28, 29). In addition, the residual nitrite left in cured meats after processing may react in the gastrointestinal tract with free amines, forming carcinogenic N-nitroso compounds. Model experiments with laboratory animals have shown that high concentrations of nitrite and certain amino compounds induced tumors characteristic of the corresponding N-nitroso compounds (28, 30). Because of the formation of nitroso compounds from nitrite and amines in the stomach there is a definite need to reduce the amount added to our foods. This was strongly recommended by the toxicology experts of the International Symposium of Nitrite in Meat Products that took place in Zeist, The Netherlands, September 11 - 14, 1973.

The experiments conducted by the Natick Development Center researchers show that the additions of nitrite to cured, smoked ham and bacon can be reduced from 156 mg/kg, the amount commonly used by the meat industry, to 25 mg/kg in radappertized meats without affecting the characteristic color, odor, flavor and overall acceptance of the products and with the guarantee that no Cl. botulinum toxin will be formed (31, 32). Table VI shows the preference data for the low and high nitrite radappertized ham. The data indicate the high quality products containing only 25 mg/kg sodium nitrite and 100 mg/kg sodium nitrate added to the products during curing, instead of the commonly used 150 - 156 mg/kg nitrite and 500 - 600 mg/kg nitrate. The important factor in achieving this notable reduction by 83% is the fact that radappertization destroys Cl. botulinum, thus eliminating the need for that amount of nitrite required for controlling Cl. botulinum in nonirradiated cured meats.

Spices generally have high bacterial counts. When other foods are seasoned with spices, the spices are the foci for rapid bacterial growth. Although ethylene oxide has been used to reduce the bacterial population, it leaves an undesirable residue (33). Heat is unsatisfactory because it drives off or destroys the desirable volatiles which are characteristic of spices. Work by Polish (34) and Hungarian (35) investigators has shown that radappertization is highly effective and can be substituted for ethylene oxide.

The onset of mold spoilage on orange peels is delayed by biphenyl. This chemical has been suspected of being a carcinogen. Radurization (75-300 Krad) of citrus fruit has been demonstrated to achieve an equivalent delay in onset of mold spoilage and can be used as a substitute for this chemical.

SAFETY FOR CONSUMPTION (WHOLESOMENESS)

As described under Legal Aspects, the FDA and USDA (for meat and poultry) must grant approvals to petitions before irradiation processed foods can be produced, sold, or eaten in the United States. Although the Armed Forces are exempt from this legal restriction, it is the Army Surgeon General's policy to use this exemption only in national emergencies. Now that it is scientifically possible to produce irradiated food products of excellent quality which could be phased into both military and civilian feeding, the main thrust of the Army's Food Irradiation Program is to provide data convincing to FDA and USDA to issue the necessary approvals. The major wholesomeness aspects which must be addressed in the evidence in support of petitions are nutritional quality, inability to measure induced radioactivity, freedom from pathogens and their toxins, and absence of toxic, mutation-inducing, cancer-forming or birth defect-inducing (teratogenic) compounds.

The challenge has been successfully met for the first three of the four aspects involved in proof of wholesomeness through control of the processing procedures, including the food itself, and limiting the use of radiation sources to the gamma rays of cobalt-60 and cesium-137, X-rays (below 5 MeV) and electrons (below 10 MeV). Additional evidence, if required in support of any particular petition, can readily be obtained experimentally quickly and at low cost.

It is the 4th aspect, demonstration of the absence of toxic, teratogenic, carcinogenic, and mutagenic compounds that is difficult, time-consuming, and costly. In the United States, the Army Medical Department, during a 10-year period (1955 - 1965), studied 21 foods irradiated with gamma rays or 10 MeV electrons to an absorbed dose of 5.6 Mrads representing all classes of foods in the diet of North Americans and concluded that these foods are as wholesome as nonirradiated foods (36).

Despite the enormous amount of work previously accomplished, the general lack of approvals of irradiated foods by regulating agencies indicates that earlier protocols for wholesomeness testing proved inadequate when viewed against more contemporary yardsticks brought about by ever increasing knowledge. As experience was gained with succeeding animal feeding experiments, new parameters for study were then added. As an example, irradiated bacon was approved by the FDA in 1963. This approval was rescinded in 1968 upon re-examination of the same experimental data which was resubmitted in support of a petition for irradiated ham. The reasons for this rescission were based on the fact that the work conducted in the 1950's as re-evaluated in light of the "state-of-the-art" in the 1960's was found to be insufficient to prove wholesomeness (37, 38).

In spite of the FDA 1968 decision, we believe that irradiated foods are wholesome and have continued to demonstrate this wholesomeness through additional animal feeding studies. Many countries outside the United States have reported a number of short-term and long-term animal feeding studies that have been completed since 1969 (1, 2, 38, 39, 40, 41, 42). None of the investigations indicated any incidence of chronic toxicity or carcinogenicity with the irradiated food. Some of these investigations also included mutagenecity and teratogenicity tests, all with negative results.

In 1971, the United States Department of the Army initiated a broad based study to establish the wholesomeness of radappertized, enzyme-inactivated beef (38, 43). The various areas of this study included microbiology, induced radioactivity, radiation, chemistry and food technology aspects as well as the multigeneration animal feeding studies which are outlined here.

Table VII lists the five diet groups in the dog feeding portion of the studies. Because the nutrition of the dog has not been as well defined as for the rodents, and partly because of economic factors, a commercial dog ration was selected as the negative control diet and served as the basal ingredient (65% by dry weight) of the other four diets.

The original intent of the study was to have a similar five-group design for rats and mice in which a semipurified diet would be used in lieu of a commercial ration as the negative control diet and as the basal ingredients of the other four diets. However, apparent nutritional inadequacies of the semipurified diet initially used in these studies became evident during the course of the study, and the current protocol defines two different negative control diets for both rats and mice. This change has resulted in ten diet groups for each rodent species (Table VIII).

The primary purpose of the negative control groups in these studies is to serve as an indicator of comparability of the husbandry and management practices of the individual replicates. The meaningful comparison in these studies is intended to be between the frozen, enzyme-inactivated beef and thermally sterilized, enzyme-inactivated beef groups on the one hand, and the two radappertized (Cobalt-60 and Electron Linear Accelerator), enzyme-inactivated beef groups on the other.

Table IX shows the number of animals per diet group. The large number of rodents (140 rats, 150 mice) per diet group is required to permit a sufficient number of rodents to be available after two years for adequate statistics on longevity and to allow for the periodic sacrifice of animals for histopathological examinations at three-month intervals. The large number of dogs per diet group (thirty) is necessary for adequate reproduction data.

The breeding program is outlined in Table X and follows, in general, the recommended procedure for multigeneration studies (44). Because reproduction performance was questioned in previous studies, and in order to study this more intensely than the usual breeding recommendations, the F_{2b} (third generation) rats will be bred continuously throughout their life span to determine whether under this type of challenge some defect will be exhibited either in shortened reproductive life or through some lesion.

Data are collected for the general parameters listed in Table XI, which are, in general, the generally accepted parameters for such studies (44). Any gross pathology is determined on every animal at autopsy, and if lesions are observed, microscopic examinations are conducted. However, tissues are routinely examined microscopically from rats that are routinely sacrificed (four of each sex/diet group), from all animals that are moribund or die during the course of the study, and from all F_0 generation animals. The routine analyses conducted during the study are shown in Table XII, and supporting studies are shown in Table XIII.

The animal feeding studies were completed in the summer of 1975 for the dogs and will be completed in the summer of 1976 for the rodents. Any preliminary evaluation of the present results must take into account that the animal feeding experiments are based on biological entities, and the whole composite status undergoes minor variations from day to day. Until all studies are completed and the data analyzed, no attempt can be made to draw definite conclusions regarding the wholesomeness of irradiated beef. This position is commonly taken in all investigations based upon such biological indicators, and is not unique to these studies. However, to date, there have been no indications from these studies that reflect adversely on the wholesomeness of radappertized beef. Other studies, following similar procedures used for the animal feedings with beef, will be initiated with radappertized pork, chicken, and low nitrite-nitrate ham in 1976 to assure the wholesomeness of these additional three radappertized meats.

FUTURE UTILIZATION CONCEPTS

I have mentioned earlier that the Secretary of the Army recently directed accelerating the schedule for wholesomeness testing of irradiated foods to obtain FDA and USDA approvals as soon as possible. In a Hearing held on 16 September 1966 before the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy, Congress of the United States, the principal Army witness stated (45):

> *Although commitments to utilize sizable quantities of irradiated products over an extended period must be deferred until after adequate testing, the Department of the Army has a firm and pressing need for the potential advantages of certain irradiation sterilized foods and an interest in pasteurized and other forms of irradiated products. The Army's major interest is in the area of irradiation-sterilized foods for potential use in the A-ration to replace or partially replace frozen or heat-processed counterparts, and in the B-ration to replace certain less desirable heat-processed and dehydrated items. There is also a need for the potential advantages of irradiation sterilized food items in ready-to-eat packaged operational rations. In addition, the Army has an interest in irradiation pasteurized items wherein the shelf life of a fresh product held at ambient or refrigeration temperatures is extended. The immediate need is for those irradiated products that will replace the items currently in the supply system that cannot be processed satisfactorily, from an acceptability standpoint, by freezing and/or canning, or which have limited storage stability.*
>
> *An example of an A-ration item in this category is heat-pasteurized canned ham. The canned ham requires refrigeration, has a short shelf life, has decreased acceptability when frozen, and has required very careful monitoring by the Armed Forces to avoid health hazards. The present heat-sterilized canned ham chunks or frozen boneless product are not satisfactory replacements in either the A- or B-rations. After FDA and USDA clearances are obtained for the irradiation sterilized product and if production and user tests provide satisfactory results, the Army could phase irradiation*

sterilized ham into the troop feeding system in fiscal year 1969. The estimated maximum quantities for phasing in this item based upon present feeding strengths and the planned servings as scheduled in the fiscal year 1967 annual food plan are as follows:

Fiscal Year	Forecast Maximum Annual Needs (pounds)	Primary Use[1]
1969	3,500,000	To replace canned ham overseas
1970	5,900,000	To replace canned ham and frozen ham overseas
1971	15,735,000	To replace canned ham and frozen ham world-wide

[1]CONUS consumption assumes competitive costs.

Other specific examples of forecasted Army needs for irradiation sterilized meats include:

Forecast Maximum Annual Needs

Product:	Pounds
Frankfurters	7,418,000
Luncheon meats (all varieties)	4,140,000

In addition to irradiation sterilized ham and processed meats, Army needs exist for certain types and cuts of pork, beef, and chicken. Unquestionably, further needs will become evident as the research, development, and testing program progresses.

STOCKPILING FOR EMERGENCY USE

Natick Development Center personnel in November 1974 prepared a plan for stockpiling radappertized beef, pork, poultry and sea food products using government or quasi-government facilities for emergency use before FDA and USDA approvals are received. 116,000 kg (260,000 lb) of highly acceptable and nutritious radappertized foods could be produced for stockpiling without refrigeration within 3 - 4 months after awarding contracts for procuring food, at an overall cost for the shelf-stable product ranging from $500,000 - $750,000, depending on items selected; within 6 - 7 months, about 450,000 kg (1 million lb) could be produced.

If there is a long-term commitment to a continuing large-scale stockpiling of irradiated foods, then starting three years from now 10 million kg (22 million lb) of radappertized food could be produced costing about $50,000,000 - $75,000,000.

A wide selection of foods in different containers is available now from which a choice can be made to satisfy specific subsistence requirements.

SUMMARY AND CONCLUSIONS

1. The Army has firm and pressing needs for irradiation preserved foods.

2. Under peacetime conditions, irradiated foods will not be used in military feeding situations until FDA and USDA grant approvals.

3. Data from the wholesomeness study for radappertized beef which will be completed in 1976 do not show any evidence detrimental to food irradiation.

4. Radappertized chicken, ham, and pork will commence testing for whilesomeness in 1976 under an accelerated program to obtain FDA and USDA approvals at the earliest possible date. It is expected that these approvals, coupled with that for beef, will give the meat processing industry a broad enough base and incentive to begin commercial production for meeting military and civilian needs.

5. Irradiation preservation will reduce dependence upon chemical preservatives (e.g., nitrites in cured meats) which have been questioned as health hazards.

6. Improvements in technology through radappertization at low temperature under vacuum in sealed containers have resulted in meat products with excellent nutritional and organoleptic quality and long shelf life without refrigeration.

REFERENCES

1. A. Sreenivasan, In Proceedings SOS/70 Third International Congress Food Science and Technology, Washington, DC, August 1970 (G. L. Stewart and C. L. Willey, Eds), pp. 595-603. Institute of Food Technologists, Chicago, IL, 1971. Library of Congress Card No. 73-179091.

2. F. J. Ley, Safety of irradiated food-biological aspects. In Proceedings SOS/70 Third International Congress Food Science and Technology, Washington, DC, August 1970 (G. L. Stewart and C. L. Willey, Eds.), pp. 806-815). Institute of Food Technologists, Chicago, IL, 1971. Library of Congress Card No. 73-179091.

3. E. Wierbicki, M. Simon and E. S. Josephson, Preservation of meats by sterilizing doses of ionizing radiation. In Radiation Preservation of Foods (Publication 1273, National Academy of Sciences - National Research Council), pp. 383-409, Washington, DC, 1963.

4. E. S. Josephson, A. Brynjolfsson, E. Wierbicki, D. B. Rowley, C. Merritt, Jr., R. W. Baker, J. J. Killoran and M. H. Thomas, Radappertization of meat, meat products and poultry. In Radiation Preservation of Food (IAEA, STI/PUB/317), pp. 471-490. International Atomic Energy Agency, Vienna, Austria, 1973.

5. E. S. Josephson, A. Brynjolfsson and E. Wierbicki, Engineering and economics of food irradiation. Transactions N. Y. Acad. Sci. 30(4), 600-614 (1968).

6. A. Anellis, D. Berkowitz, W. Swantak and C. Strojan, Radiation sterilization of prototype military foods: Low temperature irradiation of codfish cake, corned beef and pork sausage. Applied Microbiol. 24 (3), 453-462 (1972).

7. G. W. Shults, D. R. Russell and E. Wierbicki, Effect of condensed phosphates on pH, swelling and water-holding capacity of beef. J. Food Sci. 37, 860-864 (1972).

8. J. J. Killoran, Chemical and physical changes in food packaging materials exposed to ionizing radiation. In Radiat. Res. Reviews (Elsevier Pub. Co.), pp. 36-388, Amsterdam, The Netherlands, 1972.

9. D. R. Peryam and F. J. Pilgrim, Hedonic scale method for measuring preferences. Food Technol. 11(9), supplement: 9-14 (1957).

10. Anonymous. In AEC Authorizing Legislation, Fiscal Year 1974. Hearings, Joint Committee on Atomic Energy, Congress of the United States, 93rd Congress, part 4, March 20 and 22, 1973, page 2275. US Government Printing Office, Washington, DC, 1973

11. F. Heiligman and L. Rice, Development of irradiation sterilized codfish cakes. J. Food Sci. 37, 420-422 (1972).

12. B. O. Eggum, The effect of the thermal and radiation sterilization on the protein quality of animal feed mixtures. Z. Tierphysiol., Tierernaehr. u. Futtermittelkunde 25, 204-210 (1969).

13. D. Massa, Radiation inactivation of foot-and-mouth disease virus in the blood, lymphatic glands and bone marrow of the carcasses of infected animals. In Food Irradiation (IAEA, STI/PUB 127), pp. 329-347. International Atomic Energy Agency, Vienna, Austria, 1966.

14. K. F. MacQueen, Atomic Energy of Canada, Ltd., Ottawa. Personal Communication, 1973.

15. N. Raica, Jr., J. Scott, and W. Nielsen, The nutritional quality of irradiated foods. Radiation Res. Rev. 3, 447-457 (1972).

16. N. Raica, Jr. and D. L. Howie, Review of the United States Army wholesomeness of irradiated food program (1955-1966). In Food Irradiation, Proc. Symp. Karlsruhe, 6-10 June 1966, pp. 119-135. International Atomic Energy Agency, Vienna, 1966.

17. M. S. Read, H. F. Kraybill, W. S. Worth, S. W. Thompson, Jr., G. J. Isaac, and N. F. Witt, Successive generation rat feeding studies with a composite diet of gamma-irradiated foods. Toxicol. Appl. Pharmacol. 3, 153-173 (1961).

18. T. S. Kennedy, Studies on the nutritional value of foods treated with gamma radiation. II Effects on the protein in some animal feeds, egg and wheat. J. Sci. Food Agr. 16, 433-437 (1965).

19. F. J. Ley, The use of irradiation for the treatment of various animal feed products. Food Irradiation Information No. 1, 8-22 (1972).

20. T. Sato, Sterilization of diet for laboratory animals. Shokuhin Kogyo 13, 89-92 (1970).

21. A. Schoen and H. H. Hiller, Digestibility of rat and mice diets sterilized by gamma irradiation or steam in conventional rats. Z. Tierphysiol. Tierernachr. Futtermittelk. 27, 338-343 (1971).

22. H. Udes, H. H. Hiller, and N. C. Juhr, Quantitative and qualitative changes in a rat and mouse diet by means of various sterilization procedures. Z. Versuchstierk 13, 160-166 (1971).

23. F. J. Ley, J. Bleby, M. E. Coates, and J. S. Patterson, Sterilization of laboratory animal diets using gamma radiation. Lab. Anim. 3, 221-254 (1969).

24. M. E. Coates, R. Fuller, G. F. Harrison, M. Lev, and S. F. Suffolk, A comparison of the growth of chicks in the Gustafson germ-free apparatus and in a conventional environment, with and without dietary supplements of penicillin. Brit. J. Nutr. 17, 141-150 (1963).

25. E. S. Josephson, M. H. Thomas, and W. K. Calhoun. Chapter 14. Effects of treatment of foods with ionizing radiation in Nutritional Evaluation of Food Processing. R. S. Harris and Karmas, Editors, AVI Publishing Co., Westport, CT., 1975.

26. I. A. Wolff and A. E. Wasserman, Nitrates, nitrites and nitrosamines. Science 177, 15-19 (1972).

27. J. G. Sebranek and R. G. Vassens, Nitrosamines: a review. J. Milk and Food Technol. 36, 76-91 (1973).

28. R. Preussmann, Toxicity of nitrite and N-nitroso Compounds. In Proc. Int. Symp. Nitrite in Meat Prod. (PUDOC), pp. 217-226. Wageningen, The Netherlands, 1974.

29. L. Friedman, Problem arising from the use of nitrite in food processing. In Proc., Meat Ind. Res. Conf., pp. 11-20. Chicago, IL., 1973.

30. J. Sander, Formation of N-nitroso compounds in laboratory animals: a short review. In Proc. Int. Symp. Nitrite in Meat Prod. (PUDOC), pp. 243-250. Wageningen, The Netherlands, 1974.

31. E. Wierbicki and F. Heiligman, Shelf stable cured ham with low nitrite-nitrate additions preserved by radappertization. In Proc. Int. Symp. Nitrite Meat Prod. (PUDOC), pp. 189-212. Wageningen, The Netherlands, 1974.

32. E. Wierbicki, F. Heiligman and A. E. Wasserman, Cured meats with reduced nitrite preserved by radappertization. In Proc. 20th European Meeting Meat Res. Workers, Dublin, Ireland, September 15-20, 1974, pp. 100-102.

33. W. M. Urbain, In AEC Authorizing Legislation, Fiscal Year 1974. Hearings, Joint Committee on Atomic Energy, Congress of the United States, 93rd Congress, Part 4, March 20 and 22, 1973, page 2468. US Government Printing Office, Washington, DC, 1973.

34. S. Bachman and J. Gieszczynska, Studies on some microbiological and chemical aspects of irradiated spices. In Aspects of the Introduction of Food Irradiation in Developing Countries (IAEA, STI/PUB/362), Panel Proc. series, pp. 33-41. International Atomic Energy Agency, Vienna, Austria, 1973.

35. J. Farkas, J. Beczner and K. Inche, Feasibility of irradiation of spices with special reference to paprika. In Radiat. Preservation of Food (IAEA, STI/PUB/317), pp. 389-402. International Atomic Energy Agency, Vienna, Austria, 1973.

36. Statement on the wholesomeness of irradiated foods by The Surgeon General, Department of the Army, in Radiation Processing of Foods. Hearings before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy. Congress of the United States, June 9 and 10, 1965. pp. 105-106. US Government Printing Office, Washington, DC, 1965.

37. Status of the Food Irradiation Program. Hearings, Joint Committee on Atomic Energy, 90th Congress, U. S. Congress, 18 and 30 July 1968, Washington, DC. Government Printing Office.

38. N. Raica and R. W. Baker, The wholesomeness testing of radappertized enzyme-inactivated beef in Radiation Preservation of Food. Proceedings of a Symposium, Bombay, India, 13-17 November 1972. International Atomic Energy Agency (IAEA, P.O. Box 390, A-1011, Vienna, Austria; STI/PUB/317), Vienna, 1973, pp. 703-714.

39. Food Irradiation. Proceedings of a Symposium, Karlsruhe, Germany, 6-10 June 1966; STI/PUB/127, IAEA, Vineea, Austria, 1966.

40. L. V. Metlitskii, V. N. Rogachev, and V. G. Krushchev (USSR); Eng. Translation URNL-IIC-14, July 1968, Clearinghouse, U. S. Oepartment of Commerce, Springfield, VA, 22151, U. S. A.

41. M. L. Frumkin, L. P. Koval'skaya, and S. Yu Gel'fand, Printing House "Pishchevaya Promyslennost," Moscow, U. S. S. R., 1973.

42. D. de Zeeuw and J. G. van Kooij, Status of public health acceptance of irradiated food in The Netherlands, see reference 38, pp. 753-760.

43. H. C. Johnson, N. Raica and R. W. Baker. The wholesomeness of radappertized enzyme-inactivated beef--a progress report. Presented at the 4th International Congress of Food Science and Technology, Madrid, Spain, 22-27 September 1975. (U. S. Army Natick Development Center, Natick, MA 01760, U. S. A.).

44. The Technical Basis for Legislation on Irradiated Food. Report No. 6 of a Joint FAO/IAEA/WHO Expert Committee, Rome, 21-28 April 1964; FAO of the United Nations, Rome, Italy, 1965.

45. E. S. Josephson, in Review of the Food Irradiation Program. Hearing before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy, Congress of the United States, September 16, 1966, pp. 65-66. US Government Printing Office, Washington, DC, 1967.

TABLE I

SOME POSSIBLE APPLICATIONS OF IONIZING RADIATION TO THE TREATMENT OF FOOD

Application	Dose range (Mrad)
Sterilization to allow long-term unrefrigerated storage, e.g., for meats and meat products	4–6
Sterilization of food ingredients, e.g., spices	1–2
Extension of refrigerated storage (0–4°C), e.g., meat and fish	0.05–1.0
Elimination of specific pathogens, e.g., salmonellae from meat, poultry, and eggs, and animal feeds	0.5–1.0
Reduction of mold-yeasts, e.g., on fruits and vegetables	0.1–0.5
Destruction of parasites, e.g., in meat	0.01–0.2
Disinfestation, e.g., cereals	0.01–0.1
Inhibition of sprouting, e.g., potatoes and onions	0.005–0.015
Sterilization of laboratory-animal diets	2–5

Source: F. J. Ley (2).

TABLE II

MINIMUM REQUIRED DOSES (MRD) FOR RADAPPERTIZATION[a]
(PRELIMINARY DATA)

Food	Irradiation temperature (°C)	MRD (Mrad)
Bacon	5 to 25	2.3
Beef	-30 ± 10	4.7
Beef	-80 ± 10	5.7
Beef[b]	-30 ± 10	3.7
Chicken	-30 ± 10	4.5
Ham	5 to 25	2.9
Ham	-30 ± 10	3.7
Ham[c]	-30 ± 10	3.3
Pork	5 to 25	4.6
Pork	-30 ± 10	5.1
Shrimp	-30 ± 10	3.7
Codfish Cakes	-30 ± 10	3.2
Corned Beef	-30 ± 10	2.4
Pork Sausage	-30 ± 10	2.7

[a]Based on 10^{12} reduction in numbers of spores of Cl. botulinum (12-D)
[b]With the additives: 0.75% NaCl and 0.375% sodium tripolyphosphate
[c]Low $NaNO_2/NaNO_3$ (25/100 mg/kg)

Source: Mr. Abe Anellis, Food Sciences Laboratory, US Army Natick Development Center

TABLE III

ACCEPTANCE OF RADAPPERTIZED HAM[a]
(Hams stored at room temperature for 1 to 12 months prior to serving; testing period: October 1971 - May 1974)

Expt. No.	Recipe	No. Raters	Average Acceptance Rating[b]
71/90	Grilled	16	8.1
71/123	Baked	16	7.5
72/80[c]	Baked	17	7.7
72/80[c]	Baked	45	7.1
72/80[c]	Baked	17	7.9
72/101	Baked	25	6.6
73/17	Baked	22	7.4
73/180	Baked	14	7.9
73/46	Baked	45	7 4

[a] 3.7-4.3 Mrad at $-30 \pm 10^{\circ}C$, based on 10^{12} reduction in numbers of spores of Cl. botulinum (12-D).
[b] 9-point hedonic scale: 9 is "like extremely"; 5 is "neither like nor dislike"; 1 is "dislike extremely".
[c] APOLLO 17 ham.

Source: Mrs. Lucy J. Rice, Food Engineering Laboratory, US Army Natick Development Center

TABLE IV

ACCEPTANCE OF RADAPPERTIZED SHRIMP, PORK SAUSAGE, AND BEEF[a]

Expt. No.	Product	Recipes	No. Raters	Average Acceptance Rating[b]
71/156	Shrimp[c]	Cocktail	21	7.5
"	"	"	17	7.6
73/19	"	"	31	7.4
73/53	"	"	46	6.9
72/116	Pork Sausage[d]	Fried	28	7.5
"	"	"	23	7.4
"	"	"	17	7.2
73/65	"	"	23	7.4
71/135	Beef[e]	Brown Gravy	35	5.8
71/104	"	"	17	6.9
72/14	"	"	16	6.8
72/109	"	Mushroom Gravy	17	6.0

[a]Non-refrigerated storage: 1 to 7 months.
[b]9-point hedonic scale where 9 is "like extremely"; 5 is "neither like nor dislike"; 1 is "dislike extremely".
[c]3.8-4.9 Mrad at $-30 \pm 10^{\circ}C$.
[d]2.7-3.3 Mrad at $-30 \pm 10^{\circ}C$.
[e]4.7-6.1 Mrad at $-30 \pm 10^{\circ}C$.

Source: Mrs. Lucy J. Rice, Food Engineering Laboratory, US Army Natick Development Center

TABLE V

EFFECT OF PROCESSING ON THE VITAMIN CONTENT OF SHELF-STABLE CANNED HAM

Vitamin	Treatment	mg/100 g[a]	% retention
Thiamine	Control	3.82 ± 0.38[b]	—
	4.5 Mrad at -80° ± 5°C	3.25 ± 0.79	85
	Thermally processed	1.27 ± 0.36	32
Riboflavin	Control	1.01 ± 0.18[b]	—
	4.5 Mrad at -80° ± 5°C	1.25 ± 0.09	123
	Thermally processed	1.10 ± 0.24	109
Niacin	Control	3.15 ± 0.81[b]	—
	4.5 Mrad at -80° ± 5°C	23.8 ± 2.92	76
	Thermally processed	14.6 ± 4.49	46
Pyridoxine	Control	1.11 ± 0.15[b]	—
	4.5 Mrad at -80° ± 5°C	1.02 ± 0.12	92
	Thermally processed	0.64 ± 0.03	57

[a]Moisture, fat, salt-free basis.

[b]Average ± S.D. Three samples per treatment.

Source: Mrs. Miriam H. Thomas, Food Sciences Laboratory, Nutrition Division, US Army Natick Development Center

TABLE VI

ACCEPTANCE OF HIGH AND LOW NITRITE RADAPPERTIZED HAM[a]

(Consumer-Type Panel: n = 32)

Sample Series No.	ppm Added		Irra. Source	Acceptance Ratings	
	$NaNO_2$	$NaNO_3$		10[c] (Days)	30[c]
1	150[b]	600	Cobalt-60	6.8 ± 1.5	6.2 ± 1.7
2	25[b]	100	Cobalt-60	6.4 ± 1.5	6.0 ± 2.2
3	150	600	Electrons	6.5 ± 2.0	6.8 ± 1.4
4	25	100	Electrons	7.0 ± 1.2	6.8 ± 1.4
LSD (Least Significant Difference):				NS	0.7

[a]3.7-4.4 Mrad at $-30^{\circ} \pm 10^{\circ}C$

[b]Paired sets of samples, Cobalt-60 vs. Electrons for both the low and high Nitrite - Nitrate hams.

[c]Storage time without refrigeration after radappertization.

Source: Mrs. Lucy J. Rice, Food Engineering Laboratory, US Army Natick Development Center

TABLE VII

DIET GROUPS OF DOGS

Group Designation	Diet[a]
Group I	100% commercial dog ration.
Group II	35% frozen, enzyme-inactivated beef[b].
Group III	35% thermally sterilized, enzyme-inactivated beef[b].
Group IV	35% gamma-ray (^{60}cobalt) radappertized, enzyme-inactivated beef[b].
Group V	35% electron-(LINAC) radappertized, enzyme-inactivated beef[b].

[a]Dry weight basis.

[b]Plus 65% commercial dog ration.

TABLE VIII

DIET GROUPS OF RATS AND MICE

Group Designation	Diet[a]
Group I	100% modified semipurified diet.
Group II	35% frozen, enzyme-inactivated beef[b].
Group III	35% thermally sterilized, enzyme-inactivated beef[b].
Group IV	35% gamma-ray (^{60}cobalt) radappertized, enzyme-inactivated beef[b].
Group V	35% electron-(LINAC) radappertized, enzyme-inactivated beef[b].
Group VI	100% commercial rodent ration.
Group VII	35% frozen, enzyme-inactivated beef[c].
Group VIII	35% thermally sterilized, enzyme-inactivated beef[c].
Group IX	35% gamma-ray (^{60}cobalt) radappertized, enzyme-inactivated beef[c].
Group X	35% electron-(LINAC) radappertized, enzyme-inactivated beef[c].

[a]Dry weight basis.

[b]Plus 65% modified basal diet.

[c]Plus 65% commercial rodent ration.

TABLE IX

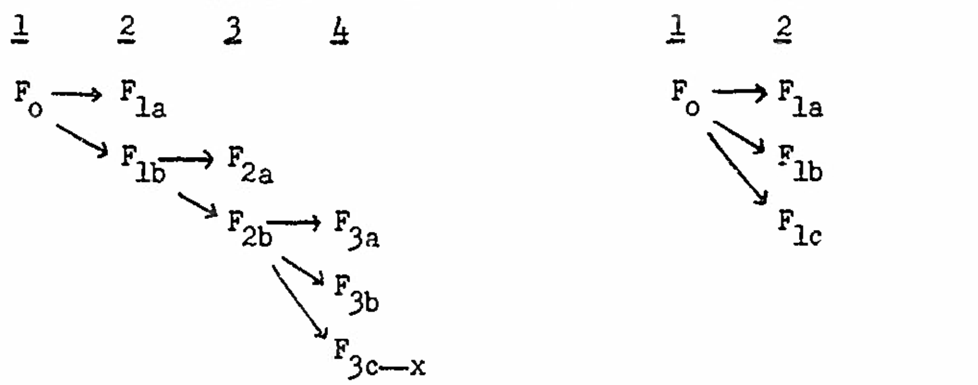
ANIMALS PER DIET GROUP

Species	Males	Females
Rats (Sprague-Dawley)	70	70
Mice (Swiss Albino)	75	75
Dogs (Beagle)	10	20

TABLE X

BREEDING PROGRAM AND GENERATIONS

Rodent[i, ii] generations — Dog[i, iii] generations



i-F_o Generation is derived from stock animals fed the respective diets prior to conception and through weaning of the F_o Generation.

ii-F_o Generation maintained on study for 2 years.

iii-F_o Generation maintained on study for 3 years.

TABLE XI

General Parameters

Growth and Body Weight
Food Consumption
Reproduction Performance
Longevity (Mortality)
Pathology:
Gross and Microscopic
Ophthalmoscopic (Rats and Dogs)
Urinalysis (Dogs)
Semen Examination (Dogs)

TABLE XII

ROUTINE ANALYSES

<u>Hematology and Chemistry</u>

Total and Differential Cell Counts
Hemoglobin and Hematocrit
Serum Protein, Albumin and Globulin
Prothrombin Time, SGOT, SGPT
Serum Alkaline Phosphatase (Dogs)
Serum Creatinine (Dogs)
BSP Liver Function (Dogs)

<u>Diets</u>

Thiamine		Riboflavin
Pyridoxine		Niacin
Ascorbic Acid		Vitamin A
	Vitamin E	

Fatty Acids	Amino Acids
Calcium	Phosphorus

Proximate (Protein, Fat, Ash, Moisture)
Peroxide Number, TBA, pH

TABLE XIII

SUPPORTING STUDIES

I. Animal Feeding Studies

- A. Antimetabolites to:
  1. Thiamine
  2. Pyridoxine
- B. Teratogenicity
- C. Mutagenicity

II. Irradiation Effects on:

- A. Fats and Lipids
- B. Protein and Amino Acids

III. Microbiology

- A. "12-D" Determinations
- B. Indigenous Microflora

ACTIVITIES ON FOOD RESEARCH AND PRODUCT DEVELOPMENT FOR THE NATIONAL DEFENCE RESEARCH ORGANIZATION OF THE NETHERLANDS

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A survey is given (Table 1) followed by a brief description of the various activities on food research and product development of the Central Institute for Nutrition and Food Research TNO for the National Defence Research Organization TNO over the last 10 years.

SUMMARIZING DESCRIPTION

1. Retorted food products

1.1. Nutritive value of canned meals

In this study, the nutritive value of six types of canned meals (military rations) was investigated, before and after sterilization, and after storage up to five years. Vitamin content, biological value of the protein, and amino acid content of the products were analyzed. Special attention was paid to the low biological value of the protein of meals containing pulses (Hellendoorn et al., 1970a).

1.2. Improving the sensoric quality of canned meals by diminution of the sterilization time

The sensoric quality of canned whole meals (consisting of a mixture of mashed potatoes and vegetables, with meat) of the conductivity type, packaged in normal cylindric 850-ml cans, can be improved by packaging in flat ham cans of the same content. A diminution of 25 per cent in sterilization time can thus be achieved.

1.3. Improving the sensoric quality of canned meals by preventing contamination of flavors

(a) The flavor of canned whole meals (consisting of meat and gravy, potatoes and vegetables) can be improved by separating the meat and gravy component from the potatoes and vegetables, thus preventing mixups of the different flavors during sterilization. Separation can be achieved in several ways, the one (using two separate cans or packaging the meat and gravy component in a pouch of sterilizable simple foil packaged in the can) giving a more complete separation than the other (using only a separating foil in the can).
(b) Flavor and consistency of complete canned rice dishes (e.g. Indonesian fried spiced rice, Paella, rice with chicken and curry sauce, rice with hashed meat and sauce, etc.) can be improved by

separating the rice from the other ingredients (instead of using sterilized canned rice, a separate pouch with dry rapid cooking rice may be preferred) (Hellendoorn and Meyer, 1966).

1.4. Improving the sensoric quality of canned meals

Effect of nitrite and/or sodium chloride on thermophylic microorganisms. 200 ppm nitrite (effecting good keeping properties in pasteurized meat products in addition to color retention) has no effect on thermophylic microorganisms in sterilized whole meals. A positive effect, however, could be observed upon addition of NaCl in 3 per cent concentration (see II: concentrated meals).

1.5. Effect of heat treatment on flavor of canned food products

The off-flavor of canned mashed potatoes (as a component of whole meals) has two aspects: a sweet and a burnt flavor. The volatile component of the sweet off-flavor aspect could be identified as iso butyr aldehyde (2-methyl propanal) and methyl acetate; furthermore, the concentration of acetaldehyde (ethanal), propion aldehyde (propanal) and diacetyl (2,3-butane dione) in the flavor of the sterilized product was increased. The components of the caramel (burnt) aspect of the off-flavor could not be identified.

An investigation on the influence of the sterilization process on the flavor of natural spices is on progress. Moreover, an investigation on the properties of extracts of spices (which are bacteriologically sound) in canned food products will be carried out.

1.6. Sterilization in laminated pouches and flexible cans

The technological conditions of the sterilization process had been investigated. The experiments were carried out in an autoclave with a glass window. The usefulness of several Alu-foil laminates that could be commercially obtained were screened. With acid meat products, corrosion of the Alu-foil occurred after storage for more than one year.

The possible use was indicated of pouches made of sterilizable simple plastic foil. A certain number of these pouches, sterilized along with the food products, may be packaged in a large can under nitrogen, or in a large pouch, made of Alu-foil laminate, under vacuum. After opening of the outer package, the individual pouches have to be distributed for rapid use.

2. Concentrated meals

Concentrated meals, which have to be made ready for consumption by boiling with the same volume of water, can in principle be prepared in the following two ways:
(1) by dehydrating a prepared meal to the desired water content, followed by canning and sterilization;
(2) by packaging and sterilization of the dry components (rice, pasta products, dry beans, dehydrated meat, spices, etc.) provided with a sub-optimal mount of water.

As to (1)

Concentrated meals, consisting of mashed potatoes and vegetables, made in the mentioned way, were unattractive (brown discoloration, burnt off-flavor).
The water-activity (A_w = 0.99) of these dehydrated food products was too high to make pasteurization feasible.

As to (2)

Attractive meals with beans could only be made with a slightly reduced water content.
Attractive concentrated rice dishes (A_w = 0.93) and noodles in tomato sauce (A_w = 0.99; pH = 4.5) with good storage stability could be obtained by pasteurization (<100°C). Packaging in pouches could be used with advantage. It was found that the addition of 3 per cent sodium chloride to a vegetable food product greatly suppressed the growth of thermophylic microorganisms, when sterilized to a low value (F_o 2.5 - 5.0).

3. Dehydrated food products

3.1. Meals, containing a mixture of mashes potatoes and vegetables

Meals, consisting of mashed potatoes, vegetables and other ingredients (onions, spices) can be composed by mixing the dehydrated components (most of them air-dried), and packaging in cans under nitrogen, or in Alu-foil laminate under vacuum.

However, these composite meals containing potatoes and vegetables can be manufactured in one step from the fresh material, in the same way as the dry mashed potato products are made, viz. as granules (add-back process), or as flakes (on a drum-drier). Even sauerkraut with potatoes could be made on a drum-drier. For the vegetable component, the blanched deep frozen product was mostly used; sauerkraut was used as the fermented product. Only the potatoes were cooked before washing and drying.

The dry homogenous mixed meals had excellent storage stability (Hellendoorn et al, 1970b).

3.2. Meat and sauce compositions

Dry meat and sauce composition were made by using dry commercially available ingredients (the meat was precooked and dried in little cubes for the producers of dry soup mixes, some of them air-dried, others AFD-dried; the sauce was made using spiced flour for sauce base, white as well as browned). The following compositions were made: beef with meat sauce, hashed meat and onions, goulash, ragout of veal, chicken with curry sauce.

These meat and sauce compositions were tabletized with the aid of 20 per cent hardened fat as a cementing agent.

These meat dishes are to be served with rice, mashed potatoes or with the above mentioned potato-vegetable mixtures.

3.3. Tablet-form meals of precooked cereal products in combination with dried fruits

Composite dry meals were developed consisting of a dehydrated precooked cereal product (rolled oats, drum dried whole wheat flakes, buckwheat flakes, rice flakes), various nuts or toasted peanuts, or toasted wheat germs, skim milk powder or soy protein isolate, apple powder, cut dry apricots, raisins, or dates, sucrose, citric acid, ascorbic acid, tabletized with 10 to 20 per cent hardened fat (mp 42°C).

Of the various components, water sorption isotherms were determined. The best way to obtain the same low water-activity (A_w = 0.15) of all the components involved consisted in low-temperature vacuum drying the mixture of the components before tabletizing.

Digestibility and net protein utilization of the protein of mixtures of rolled oats, skim milk powder (or soy protein isolate), peanuts, and of the tablets themselves, were determined by bioassay to achieve optimum protein quality. These meals are lacking calcium and vitamin A, thiamine, riboflavine, and ascorbic acid (the latter may be added).

Normally, these cereal food products are consumed after imbition with cold or hot water, or milk. In cases of emergency, however, the tablets may be eaten without prior rehydration (Hellendoorn, 1971a).

3.4. Drum drying of precooked cereals and fruits

Rolled whole wheat grains, white wheat flour, rice flour, or rolled oats are precooked, mixed with a fruit puree (apples, apricots, dates, figs), and dehydrated on the drum drier. These cereal-fruit combinations give an improved breakfast cereal over the normal precooked cereal products.

The flakes may be ground to a coarse powder, not impairing the consistency of the product after rehydration. Rice, having the faintest flavor of the various cereal products, lends itself excellently for combinations with the delicate flavor of apples and apricots. Wheat products can better be combined with comminuted dates and figs, giving less attractive dark colored products. The amount of fruit (on dry weight basis) should be from 50 to 100 per cent of the cereal product to give an end-product with an attractive fruit taste.

When prepared for consumption with cold or hot milk, curdling of the milk may occur with the acid fruit combinations. Thus skim milk powder may be incorporated in the mixtures of the cooked cereal product and the fruit puree before drying (equal amounts of rice flour, fruit puree and skim milk powder give pleasantly tasting products when rehydrated with water, and sugar added at will). The shelf life of these products is very good (Hellendoorn, 1970c).

3.5. Dehydration of food products with azeotropic vapor mixtures or by cooking out the moisture in organic solvents

Cooked meat in cubes rehydrated sufficiently. Vegetables (turnips, carrots) did not rehydrate properly.

Flavor and color of these food products were leached out; the smell of the solvent could not be removed completely.

3.6. Manufacture of a dry fried rice convenience food

In search of a more economic way of heat transport to the product than by air-drying, drying of various food products in heated fat was investigated. It was found that only precooked cereals could be dried in this way, thus maintaining excellent rehydration properties.

The rice product is made in the following way. Rice, without pre-washing, is cooked for a short time (≈ 10 min) in plenty of water to hydrate the rice grains, but not long enough to soften the grain completely. The hydrated rice grains are freed from adhering water and then placed in heated fat (165°C). As soon as evaporation of moisture ceases, the dehydration process has come to an end; it leaves about 2 to 4 per cent moisture in the grains. The adhering fat is dripped off or removed by centrifuging the rice, leaving a fat content of about 3 per cent.

The grains have a slightly yellow color. Rehydrations takes place by cooking with twice the amount of water for 10 min. This fried rice product may be used for the preparation of dry convenience foods, e.g. Indonesian fried rice dish (Hellendoorn, 1967).

3.7. Nutritionally improved French fries and potato patties

French fries and potato patties, preformed from dry mashed potato granules and egg-white, are form-resistant when frying. These potato products can be nutritionally improved by incorporating granulated dehydrated meat or (cod) fish in the mixture. Dried onions and spices can be incorporated at will.

3.8. Packaging of individual units in an over-wrap

The possible use is indicated of pouches made of simple plastic foil. A certain number of these pouches, filled with the food product and sealed under vacuum, may be packaged in a large can under nitrogen, or in a large pouch made of Alu-foil laminate, under vacuum. After opening of the outer package, the individual pouches have to be distributed for rapid consumption.

4. Starch digestibility and the physiological aspects of the indigestible residue of foods

4.1. Digestibility of dehydrated mashed potato products

The two species of dry mashed potato products, viz. granules and flakes, are hydrolyzed by pancreas amylase at a different rate, the flakes being easier to digest than the granules. By the manufacturing process of flakes on a drum drier, the rate of hydration and that of digestion of potato starch is improved; on the other hand, hardening and diminished digestibility of the starch occurred on repeated wetting and drying, which accompanies the add-back process of potato granules manufacture.

Occasionally potato granules may give rise to minor digestive disorders in man, when digestion is impaired. In the literature, little can be found on either the influence of physical and moral exhaustion on the physiology of digestion, nor on the optimum dietary measures to be taken for the restauration of the condition of men in such a condition (Hellendoorn et al., 1970d).

4.2. Aspects of retrogradation with some dehydrated starch-containing precooked food products

Phenomena of hardening of starch (retrogradation) during the manufacturing process of dehydrated mashed potato products and rice, and during ageing of rice and dry beans, are given (Hellendoorn, 1971b).

4.3. Intestinal gas formation following bean consumption

Gas formation in the intestine and flatulence are caused by fermentation in the large intestine of that part of the carbohydrates of the food which had not been digested and absorbed in the small intestine. Besides gas formation, fermentation causes increased transit of the food residue through the intestine (Hellendoorn, 1969, 1975a).

4.4. Physiological importance of indigestible carbohydrates in human nutrition

A survey is given of the physiological effects of the non-digestible part of the food in man (counteracting constipation, thus preventing the causation of many non-infectuous afflications of the colon to which people on Western low-residue diets are especially liable, and lowering of the serum cholesterol level) on the basis of the fermentation hypothesis (Hellendoorn, 1973a, 1975b).

4.5. Enzymatic determination of the indigestible residue (dietary fiber) content of human food

A simple in-vitro method, using digestive enzymes, is given for the estimation of the non-digestible residue content of foods. It appears that in most food products this indigestible residue content, which represents the calorically unavailable part of the food, is much greater than the chemically determined crude fiber values which can be found in food composition tables (Hellendoorn, 1973b, 1975c).

LITERATURE

E.W. Hellendoorn and J.C.G.M. Meyer. 1966. Conserva 15 (6): 156-160 (in Dutch)

E.W. Hellendoorn. 1967. Conserva 16: 1-2 (in Dutch)

E.W. Hellendoorn. 1969. Food Technol. 23 (6): 87-92

E.W. Hellendoorn, A.P. de Groot, L.P. van der Mijll Dekker, P. Slump and J.J.L. Willems. 1970a. J. Amer. Diet. Ass. 58: 434-441

E.W. Hellendoorn, J.C.G.M. Meyer and C. van Gorkom. 1970b. Voedingsm.technol. 1 (20): 343-344 (in Dutch)

E.W. Hellendoorn, J.G.C.M. Meyer and J.G. v.d. Kamp. 1970c. Voedingsm.technol. 1: 363-365 (in Dutch)

E.W. Hellendoorn, M. van den Top and J.E.M. van der Weide. 1970d. J. Sci. Food Agric. 21: 71-75

E.W. Hellendoorn. 1971a. Voedingsm.technol. 2 (4): 11-18 (summary and tables in English)

E.W. Hellendoorn. 1971b. Stärke 23: 63-67

E.W. Hellendoorn. 1973a. Voeding 34: 618-636

E.W. Hellendoorn. 1973b. In: Nutritional improvement of food legumes by breeding, Max Millner ed., PAG, New York

E.W. Hellendoorn. 1975a. In: Nutritional aspects of common beans and other legume seeds as animal and human food. Arch. Latinoamer. Nutr. (special number)

E.W. Hellendoorn. 1975b. In: Dietary fiber in nutrition. CRC. Critical reviews in food science and nutrition, to be published

E.W. Hellendoorn. 1975c. J. Sci. Food Agric., to be published

Table 1 - Survey of the Activities on Food Research and Product Development. I Retorted Food Products, II Concentrated meals, III Dehydrated Food Products, IV Starch Digestibility and Indigestible Residue Contents of Foods

I Retorted food products	II Concentrated meals	III Dehydrated food products
1. <u>Nutritive value of canned meals</u> Influence of sterilization process and prolonged storage on protein quality and vitamin content 2. <u>Improving the sensoric quality of canned meals</u> By diminution of the sterilization time 3. <u>Improving the sensoric quality of canned meals</u> By preventing mix-ups of flavors 4. <u>Improving the sensoric quality of canned meals</u> Effect of nitrite and/or sodium chloride on thermophylic organisms 5. <u>Effect of heat treatment on flavor of canned food products</u> Off-flavor of canned mashed potatoes; alteration of flavor of canned natural spices 6. <u>Sterilization in laminated pouches and flexible cans</u> Insufficient storage stability of acid products	1. <u>Concentrated meals</u> Which need the same volume of water for preparation	1. <u>Meals containing a mix of mashed potatoes and vegetables</u> These composite meals may be manufactured as granules (add-back process) or as flakes (on a drum drier) 2. <u>Meat and sauce compositions</u> - beef and meat sauce - hashed meat and onions - goulash - ragout of veal - chicken with curry sauce to be served with mashed potato products or with rice 3. <u>Precooked cereal products with dried fruits in tablet form</u> Which can be eaten dry or as a porridge 4. <u>Drum drying of precooked cereals and fruits</u> Manufacture of cereal flakes with fruits 5. <u>Alternative drying procedures</u> Dehydration of food products with azeotropic vapor mixtures or by cooking out the moisture in organic solvents 6. <u>Manufacture of a dry fried rice product</u> A convenience fried rice product 7. <u>Nutritionally improved French-fries and potato patties</u> Made from mashed potato granules with protein additives 8. <u>Packaging of several pouches in an over-wrap</u>

Table 1 continued

IV Starch digestibility and the physiological aspects of the indigestible residue of foods

1. Digestibility of dehydrated mashed potato products
   Starch of flakes is easier to digest than that of granules

2. Retrogradation phenomena with mashed potato products, with rice and with dry beans
   Aspects of hardening of starch

3. Intestinal gas formation following bean consumption
   Intestinal gas formation is the result of fermentation of unabsorbed carbohydrates

4. Physiological importance of indigestible carbohydrates in human nutrition
   Inconvenient aspects of fermentation: intestinal gas formation and flatulence
   Favorable aspects of fermentation: decrease in transit time of the food residue through the digestive tract counter-acting constipation, thus preventing the occurrence of non-infectuous afflictions of the colon; serum cholesterol lowering action

5. Enzymatic determination of the indigestible residue (dietary fiber) content of human food
   The indigestible residue content of most food products is much greater than the crude-fiber content. The non-digestible residue content is an unavailable part of the food.

THE FEEDING OF THE BRITISH ARMY IN 1975

By Major N. S. Nash

Gentlemen,

Good morning. My name is "Tank" Nash. I do hope you can all hear me. I'm sure that, in fact, you can but you see, I gave a talk recently in UK and my assistant said afterwards that no one had heard a word. To make me feel better, he said that I'd gone down very well. I was given notice some months ago that I was required to address you this morning for 20 minutes on "The Feeding of the British Army in 1975." You know I feel rather like the chap who was given 20 minutes to paint the Colden Gate Bridge--I'm not quite sure where to start nor am I sure which bits to leave out.

The feeding of the British Army is the task of the Army Catering Corps. There are about 5,000 of us worldwide supported by some civilians. I would like to show you a chart showing them broken down by age and sex, but I can't because I found that most of them are. 99.994% are getting on with the job right now--feeding the Army that is. The balance, that is myself and two ACC warrant officers, are on the staff of the U.S. Army Quartermaster School where I'm Chief of the Culinary Skills Division.

We live in a very sophisticated age, and in feeding the British Army, we depend upon one of the most complex tools ever devised. This instrument is priceless, its virtuosity is limitless, and in addition, it's small, compact, easy to clean and has an operating life of 22 years. I am in a position this morning to reveal to you our secret weapon. It looks like this:

<u>SLIDE of an ACC soldier in Chef's Whites</u>

In order to feed its men, the British Army has for the last 34 years invested not in expensive raw materials nor in manufactured foodstuffs ("convenience foods" as the marketing people like to describe them), but instead it has concentrated upon producing a Corps of skilled caterers and chefs who have the ability to turn the culinary "pigs ear" into the gastronomic "silk purse."

An inept cook can spoil the best commodities and he is a luxury that we can't afford nor do we tolerate. The British soldier demands the highest standard of food both in barracks and in the field and why not? -- because under our system he pays for it. It is worth noting that we provide a service about which our customers are invited to complain three times a day. General Gisp may be able to send his chaps out with a bag of rice and a blessing, but in the Western Armies we don't have that option--well, perhaps we do, but if we took it up it would play havoc with recruiting.

There's not an army in the world that doesn't seek to reduce the length of the logistic tail and the British Army is no exception. Every man is of necessity a soldier first and a tradesman second. For example, an Infantry Battalion has 21 cooks. Now that's pretty well a platoon's worth and these men must be able to feed their comrades under all conditions and often on their own initiative. Cooking is not enough. In addition, we expect them to be as skilled with this:

<u>SLIDE Fountain Pen</u>

as they are with this:

<u>SLIDE Self-Loading Rifle</u>

The ACC soldier serves with all arms learning from each as he moves around and spending on the average about 3 years in each unit. HM Foot Guards, who you will recognize from all the tourist literature, have ACC soldiers on their strength as do Parachute Units, Commando Regiments, hospitals, ships, and the infinite variety of training establishments. They must be able to function in snow and ice, jungle or desert. We train them to do just that.

Because time is short, I will only be able to deal briefly with the ACC soldier's training.

He advances up two separate career ladders. The first is that of Craft training--cooking skills if you like-- and on the slide you can see the progression:

<u>SLIDE Craft Career Ladder</u>

The ACC recruit is first taught the basic military skills-shooting, drill, fieldcraft, weapon handling, map reading, endurance, and more shooting. This accounts for the first 6 weeks and by now our recruit is starting to look like a soldier. The next step is to make him a cook. He spends 21 weeks under close supervision being taught the chef's skills interspersed with more shooting, map reading, weapon handling, and yes, you guessed it, even more shooting. At the end of this 21 weeks and about 7 months after he joined the Army, he is dispatched in the cold hard world as a Group B Class 2 Cook and has won a certificate from the City & Guilds of London(7061)which recognizes his craft skills at that level.

He joins a unit and adds to his classroom knowledge that magic ingredient we call experience. (Experience is shaving with your eyes closed--and knowing where to put the sticking plasters).

Our recruit returns some 4 years later with experience (and a face full of sticking plasters) for his next technical course and this lasts 6 weeks. Again, success is accompanied by a civilian institute's qualification 7062. Finally, after about 9 years service, he returns to take this premier course which carries with it the highest qualification in the United Kingdom. The student is a capable, seasoned, mature soldier and after this course a Chef - by any National or International standard you care to apply.

Whilst these different levels of craft qualifications are obligatory for the soldier mounting the promotion ladder, I must emphasize that any soldier in the Corps, irrespective of leadership qualities, may climb the craft ladder during his service.

The intervals between courses that I gave you are the norm and have been fixed at these stages to ensure that further advanced training is built on the firm foundation of experience and practice and at the same time ensure that those who serve the longest are given the opportunity for the higher levels of training. In other words, the soldier gets a 'pay off' and so does the Army.

There are, of course, special arrangements for the "flier"--the chap in a hurry and on his way to the top. We accelerate his progress and allow the selected soldier to attend the advanced courses at shorter intervals.

There you have the ACC soldier's technical, let's call it cookery, training. By no means all formal classroom education but a blend of formal instruction and "on the job" training spread over about 9 years.

In passing, I would mention that the Army School of Catering. . .

<u>SLIDE of Army School of Catering</u>

...where I commanded Cookery Training Wing before taking up my present appointment, produces more chefs at the premier level than all the other Technical Colleges in the country put together. The role played by the Army in catering in the United Kingdom is, I think, put into perspective by that fact.

The second career ladder is that of Catering Management and on the screen you can see the three main levels at which we train the soldier.

<u>SLIDE of Management Ladder</u>

These levels of instruction are interspersed with the cookery training thet you saw on the previous slide. In this aspect of a soldier's training, we seek to give him a wider appreciation of the catering function and the aim is to convert our 20 year old cook into a 30 year old caterer. He is taught how to organize kitchens and the people who work in them and how to plan, cost, and execute major feeding commitments. He is taught those management skills that are as applicable in the military catering environment as they are in a motor car factory. We expect him to know about motivation and read Peter Druker for fun!

The training given to the soldier as he progresses up this ladder is also recognized by the civilian industry end his Catering Administration and Management Course (CAM on the slide) carries with it the National Examination Board's certificate in supervisory studies. CAM advanced wins the soldier an enhanced certificate.

The soldier's technical skills (that is how good a craftsman is he) allied to these management skills (how well can he cater) determine his rank and thereby his appointment and his responsibilities.

It's a hard cruel world. We chaps here this morning can't all be generals (more is the pity) nor can every young ACC soldier be a warrant officer and an AI Chef. Talent is a prerequisite and all men are not equal, despite what you read in the newspapers. We do, however, give all soldiers an equal opportunity. What they choose to do with the opportunity is up to them.

I have already mentioned that each level and type of training that we give to the ACC soldier is recognized by an appropriate professional institute concerned with the catering industry. Let me make it quite clear that we do not train to standards specified by those professional institutes. We train to meet the military requirement and our training is subject to constant evaluation and development under the principles of instructional technology. The fact that the professional institutes recognize our courses of instruction, the standards we achieve, and are happy to grant our soldiers their appropriate certification is an indication that the performance levels we require to meet the military requirement are at least up to or beyond those required by those civilian professional institutes.

It's often said that "Old soldiers never die; they only fade away." In our case, it would be more accurate to say that "Old soldiers never die; they become valuable members of the civilian catering industry."

British Army philosophy is based upon a soldier having two careers. The first is 22 years in the Army leaving at about the age of 40. The second career is that quarter of a century of productive working life left to him in civilian life.

The longer a soldier serves up to the maximum of 22 years, the better qualified he will be to take his place in the industry outside. Money spent on the training of our soldiers is not only used to the benefit of the Service but is returned to the tax-paying community in the shape of a skilled, experienced and I may add, disciplined work force.

I've now discussed in very broad terms the training of the British Army's cooks and caterers and the time would now seem ripe to move on to operations.

The catering operation in individual units is the responsibility of the senior ACC non-commissioned officer. Some very large units have an ACC officer on strength but they are very few. About US $1 (52p) per day is allowed to the caterer to feed his customers and with that he is expected to produce three meals a day including the Englishman's traditional breakfast. Contrary to popular belief, it consists of rather more than tea, toast, and "The Londom Times." All meals for soldiers are on a self-service cafteria basis. This means that a soldier may help himself to the dishes of his choice taking as much or as little as he requires. Obviously, a soldier who has just completed a forced march is going to eat more than his comrade who has been employed on clerking duties. Similarly, a soldier who eats a light lunch will probably stoke up at the evening meal. This may appear to be an imprecise way to cater, but, in fact, unit feeding patterns quickly emerge and the NCO or warrant officer is able to produce the correct quantities of the desired dishes 3 times a day, 7 times a week, without needing to resort to crystal gazing.

Catering is a precise skill. It calls for judgement and often this judgement has to be exercised under extreme mental and physical pressure. The caterer who could be a young corporal running a small Officers' Mess or a Warrant Officer feeding a Regiment must be capable of balancing his budget and controlling his staff. I would emphasize at this point that we operate a cash system of provisioning, that is to say, the caterer buys individual commodities as he requires them from Service sources with the cash allowance of about US $1 per day I mentioned a moment ago. There is no physical handling of money involved. It's an accounting exercise in which all commodities are reduced to a cash value. The caterer at all levels is obliged to be cost conscious. The soldier does not pay for his food at a check-out point in the cafeteria but appropriate deductions are made from his pay.

I have told you that catering control is decentralized to unit level, there is no master menu, and each Master Cook runs his own independent show and is answerable to his Commanding Officer. At formation level, however, there is a Catering Advisory/Inspection Team usually led by a Major. These specialists, who are all ACC, are fully occupied in paying regular visits to units of their concern advising on techniques and maintaining the unit's catering standards in all its many aspects.

You will recall that I mentioned that the majority of units are not provided with a full-time specialist catering officer to manage and administer the unit's catering. Whilst the Catering Advisory Service allotted to each formation helps to maintain standards within the majority of units, its effect is limited when compared with what could be achieved if full-time officer level catering management were available in all locations.

To provide officer cover for each unit in the British Army would incur a large and unacceptable manpower bill. At the last count there were only 176 officers in my Corps and rather like the white rhinocerous we are a protected species and to mix my metaphors even more, like a fine quality marmalade, we are spread rather thinly across the toast. In order to resolve this situation, we have devised what we term "The Group System of Catering Control." The first of these Groups wss established in Aldershot in the mid-1960's with the task of providing full catering support for all units within a prescribed geographical area.

The staff for the Group organization is provided by compensating reductions in the units served by Group. The savings produced by this system, not to mention the maintenance of s higher standard of catering more cheaply, has been considerable. A few examples of the savings made are that:

a. One catering account is maintained instead of 30 with, of course, consequent savings in clerks.

b. Expert catering management at officer level is given to all units in the Group.

c. Five vehicles deliver foodstuffs instead of t e 30 vehicles and drivers employed under the old system.

d. A central team of butchers provide correctly prepared meat instead of 30 individuals working in 30 different locations to 30 differing standards.

e. A central team of pastry and larder chefs producing items ordered by units and of a quality ordained by the Group Commander.

In short, the Group System centralizes the preparation chores in each of a large number of kitchens saving manpower and releasing for more skilled tasks those directly involved in meal production in the units.

I've covered training snd operation and, gentlemen, time is now short and I must draw to a close. There are, I think, four major points I would like to leave you with. These are:

FIRST The Army Catering Corps soldier and his training are the hub of the British Army Catering System.

SECOND The Army Catering Corps soldier is soldier first - Cook second.

THIRD Units of the British Army are independent in catering matters unless they are so located that they can be "grouped" and the catering put under command of a senior ACC officer.

FOURTH The civilian industry benefits from an effective, well-trained Army Catering Corps.

I'm sorry. I didn't quite get the Golden Gate Bridge painted, but I hope that in 20 very short minutes, I gave you some insight into the "Feeding of the British Army in 1975."

We caterers do take our job seriously, but life would be rather dull if we didn't laugh at ourselves from time to time. I would like to give each of you now, with my compliments, a copy of a small book called, Any Complaints, which illustrates in a totally biased, unbalanced honest way, the way the Army Catering Corps sees itself. Any similarity with persons living or dead is the result of hard work.

Thank you for your time and for listening to me.

CENTRAL INSTITUTE FOR INDUSTRIAL RESEARCH
Blindern - Oslo - Norway.

KGA/nb
10.10.75

More technology in time of crisis

Dr. Karl G. Arnestad

The title of my short presentation should rather be named: "Too much technology in time of crisis". It expresses a fear that advanced technology pleces certain countries in a m re vulnerable position than ever before.

Being interested in food, history and politics, I find they have at least one thing in common, namely food.

It is not necessary to stress that food is and always has been the basic need of all peoples, rich and poor, powerful and weak, soldier and civilian, including citizens of this country and other great countries.

Man's most ancient preoccupation has been his fight for food. From the time the early hunters stalked the mammoths, man has battled hunger. History is replete with his failures. The world food situation today is probably more serious than it was a few years ago, due to increasing population and a steadily growing quest for higher quality diets.

No war can be successfully fought without food, preserved or otherwise processed to improve its keeping. Feeding the soldiers has changed through the years. The Romans based their marches on hard-baked bread. The Tartar horsemen of Central Asia depended on the milk curd carried in skin bags. A cheese was made out of mares milk. Preserved food has always played a decisive role in war operations. That was very evident during World War II. But soldiers today have no horses and no food can be squeezed out of modern war equipment. They must base their survival on modern food technology.

I would like to dwell a little on the development and changes in food technology and food processing.

Down through the ages, the provision and preservation of food was chiefly a task for the individual rather than the community. The flour used for baking was milled at home, partly with water-driven mills. Slaughtering and preparing the meat, as well as making butter and cheese, salting or drying fish and other products, took place on the farms. This function is now in the process of being transferred entirely from the individual to industrial plants. The self-sustained farm is a thing of the past, at least in highly industrialized countries.

Today's food processing plays a key role in modern industrial society. I agree with Professor George Borgstrøm that no civilization ever flourished without a corresponding development in food storage and preservation. The feeding huge urban communities living remote from food-production regio is an obvious result of this development.

This situation has come about as a result of the fantastic growth of food technology. Agriculture, inclusive horticulture and fisheries, have become vitally dependent on food processing. An increasing amount of the food we eat has gone through manufacturing processes (that is, conversion of the raw materials from the farm into a form suitable for eating).

There are, however, many features which are common to most processed foods in this progress from farm to consumer.

One, if not the most important stage is the farmers job, namely the collecting and harvesting of food. These raw materials, meat, milk, vegetables and so on, are, or should be, conveyed as rapidly as possible to the site of manufacture to prevent deterioration. Ideally, the raw materials should be processed immediately, but this is seldom possible.

Provisions must therefore be made for adequate storage of raw materials at the point of origin. For delayed marketing, meat and most other products are chilled or frozen. As an ever-increasing percentage of raw materials is earmarked for processing the storage in large low-temperature, cold stores is a must. Cold storage warehousing is a stabilizing force in almost any food industry, from milk to fruit, fish and meat. The meat industry as we know it today, with aging of carcasses to improve the beef quality, could not have been developed without refrigeration.

Facilities for food freezing and retail distribution are a fairly recent development, having first atarted before the last war. Yet, it was not until the post-war yeara that frozen products became important competitors of other consumer-type preserved foods. Low temperature today means much more than keeping raw materials from deterioration.

A highly essential part of the cold chain for food is refrigeration in the retail store. Without it, there would be little business in perishable foods. Restaurants and institutions that provide food services to the public rely heavily on refrigeration.

The last link on the cold chain is the home refrigerator and freezer. Norway is today highly refrigerated, also in summer. Over 70% of the households have their home-freezer cabinet, and refrigeration plays a great role in the every day life of the families.

The process of quick-freezing opens many possibilities for mass production, packaging, branding and marketing of many pre-cooked food items, such as TV dinners.

Without going into further details of food manufacture, it should be emphasized that there are few foods that are completely unprocessed.

And - this is very important - almost all foods are partly or completely dependent on the presence of one thing - refrigeration - in other words: electric power. And everybody will agree that electric power is a commodity found practically everywhere.

But what can happen to this useful, universal power in time of crisis?

Let med try to explain or exemplify what can happen to our beautiful and beloved technology even in a small crisis.

It is not necessary to talk of wars. Everybody knows what that means. But if a small crisis can bring our technology out of balance, what would happen under more serious conditions?

I suppose everybody remembers the black-out in New York a few years ago, due to failure in the supply of electricity. A similar situation occured in Munich this year. For a few hours the whole town was completely dark. All elevators immediately stopped. Trains stood still in their tunnels; telex clattered to a halt; department stores and small shops were darkened and their electric cash registers rendered useless. All homes were plunged into darkness, and thousands of refrigerators and deep freezers were getting warmer every minute. And of course all cold stores for meat and other products were affected. Not to mention tens of thousands of refrigerated display cases and batteries of reach-in refrigerators for dairy products.

This leads up to the main question in my presentation. What would happen if such a blackout lasted 4 weeks instead of 2 hours?

In the last war we had Pearl Harbour. Could it be possible for a potential enemy to hit a country through destruction of its electricity? Not in this large country, but in a smaller one?

I am afraid that not everybody clearly understands how dependant modern technology - including the entire food industry - is on electricity. It is the life blood of our technology.

Feeding the military man in peacetime is easy. But in time of crisis, or wars, he can hardly depend on the presence of electricity and frozen meals for his survival. He must rely on more conventionally prepared food products.

If a country's food supply is being destroyed through lack of electricity, the military man is responsible not only for his own survival, but for the civilians' as well. That means an extra load to carry.

To make a summary of s somewhat theoretical fear-picture:

Modern food production in industrialized countries in the post-agricultural economy is very dependent on a country's supply electricity. A minor crisis such as a regional blow-out of this power has severe effects on the entire society.

To a potential enemy, an attempt to destroy the sources of this electricity should look very tempting and well worth to try.

Indeed, sabotage in the future may prove a most effective means for a potential enemy to obtain success. That must be prevented.

Consequently, provisions for the military man as well as civilians, must necessarily rely on sources of foods that are not easily destroyed.

Around 1000 years ago, the vikings ate birch-harked bread in Norway. Before that, the Roman soldiers ate cerial soups. Both groups endured hard action with success; old experience may be good to remember in a possible crisis in our days, perhaps in evoking a complete reversal in our thinking about these matters.

CUSTOMER MORALE & BEHAVIORAL EFFECTIVENESS

ACCOMPLISHMENTS AND GOALS OF PSYCHOLOGICAL STUDIES OF FOOD SERVICE SYSTEMS

By

Harry L. Jacobs and Herbert L. Meiselman

Behavioral Sciences Division

Food Sciences Laboratory

Natick Development Center

Third International Meeting:
Foods for the Armed Forces

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U.S. Army Natick Development Center

Natick, Massachusetts 01760

INTRODUCTION

Dr. Meiselman and I are both happy to have been able to participate in these stimulating meetings and to discuss the role of the behavorial sciences in our food program at these laboratories. Although psychologists have little or no continuing and direct input into military feeding systems in Europe, this has not been the case in the United States. In this country, psychologists have been an integral part of military feeding research and development for almost three decades. Our purpose in this paper is to present (A) our general role in food system reseerch, (B) a sample of what we do now, and (C) some suggestions as to how and where we might broaden our contribution in the future.

GENERAL ROLE OF BEHAVIORAL SCIENCES IN FOOD PROGRAM

What is our general role? Figure 1 shows the relationship between our Behavioral Sciences Division and the major functions of the Natick Development Center. In general terms, our role is to study carefully the Food Service System from the point of view of the Consumer, and to supply our data and conclusions to the decision-makers involved in Product Development and Menu Planning, and System Design and Evaluation, who then apply it directly to the Food Service System as a whole.

It has been our experience that most of the "spontaneous" information available to the decision-makers about the operation of military food service becomes known through anecdotal and informal channels, via unsolicited letters, or by word of mouth, from soldiers, mothers, congressmen, and occasional visiting dignitaries. This information is usually based upon casual observation and informal questions put to members of the Armed Forces that make lasting impressions on the observer, but are usually not very reliable or valid. It is our role to supplement this "common sense" information by obtaining more objective (unbiased) data that is reliable and capable of external validation. We obtain these data by the development and use of questionnaires, interviewing techniques, and observation in Field and Garrison situations. As shown in Figure 2, our major concern is to maximize "Consumer Acceptance" by studying and obtaining information about Food Products, Food Equipment, the Consumer, and the System.

SPECIFIC WORK AREAS IN BEHAVIORAL SCIENCES

Figure 2 gives some specific examples from our program, listing some of the areas of current work in our Support Activities and services to the product laboratories here at Natick, and our Laboratory and Field Studies, which have a very close relationship with our Support Activities. Let us go through these areas, to give you a feel for the kinds of things we are doing.

Unlike the organizational chart separateness suggested in Figures 1 and 2, there is much overlap between the support activities in response

Figure 1. Role of Behavioral Sciences Activities in Research and Development in Food Service Systems: General Outline.

Figure 1

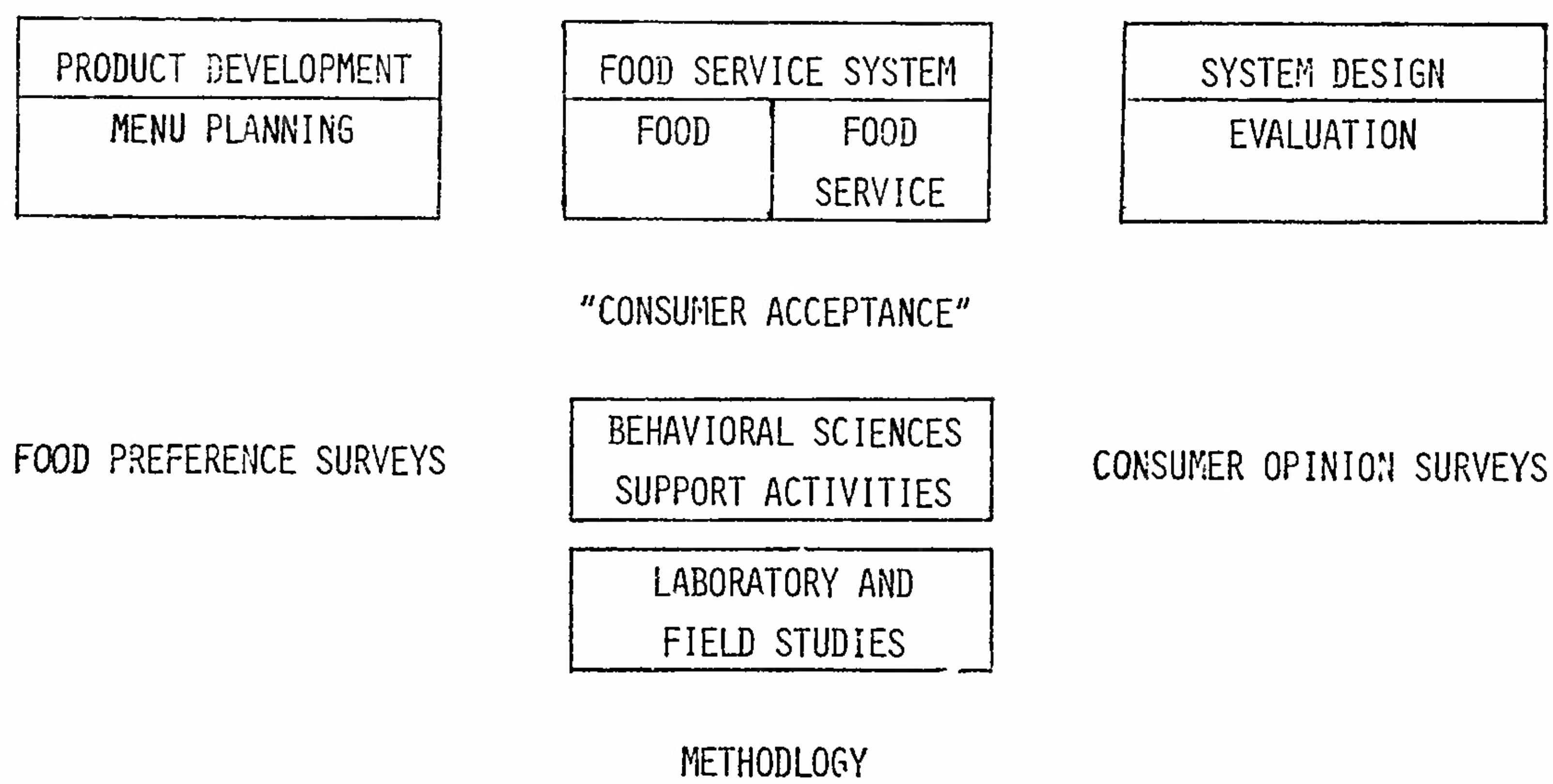
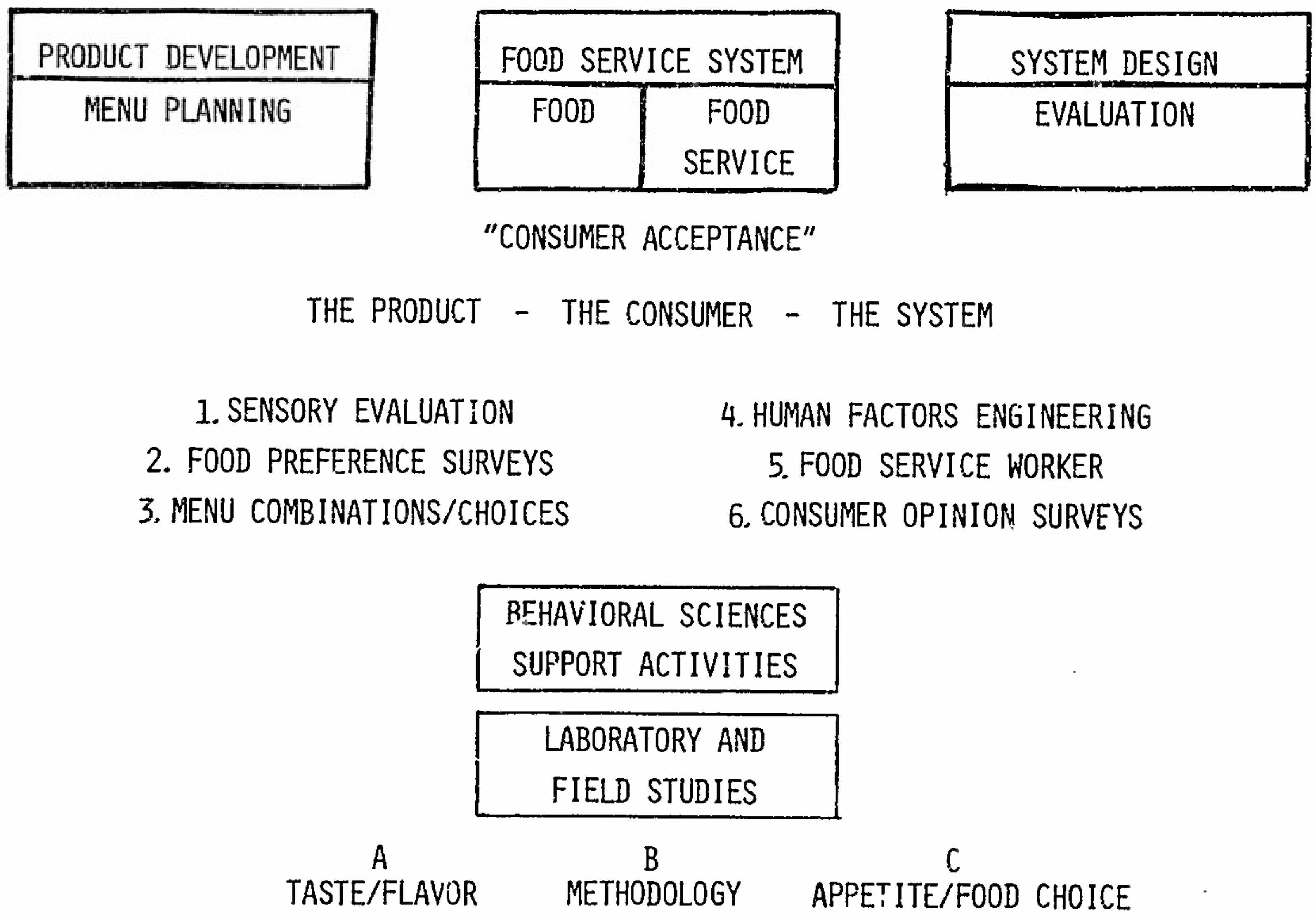

PRODUCT DEVELOPMENT
MENU PLANNING
FOOD SERVICE SYSTEM
FOOD
FOOD SERVICE
SYSTEM DESIGN
EVALUATION
"CONSUMER ACCEPTANCE"
FOOD PREFERENCE SURVEYS
BEHAVIORAL SCIENCES SUPPORT ACTIVITIES
CONSUMER OPINION SURVEYS
LABORATORY AND FIELD STUDIES
METHODLOGY

Figure 2. Role of Behavioral Sciences Activities in Research and Development on Food Service Systems: Specific Examples.

Figure 2


PRODUCT DEVELOPMENT
MENU PLANNING
FOOD SERVICE SYSTEM
FOOD
FOOD SERVICE
SYSTEM DESIGN
EVALUATION
"CONSUMER ACCEPTANCE"
THE PRODUCT - THE CONSUMER - THE SYSTEM
1. SENSORY EVALUATION
2. FOOD PREFERENCE SURVEYS
3. MENU COMBINATIONS/CHOICES
4. HUMAN FACTORS ENGINEERING
5. FOOD SERVICE WORKER
6. CONSUMER OPINION SURVEYS
BEHAVIORAL SCIENCES SUPPORT ACTIVITIES
LABORATORY AND FIELD STUDIES
A
TASTE/FLAVOR
B
METHODOLOGY
C
APPETITE/FOOD CHOICE

to the direct food requirements of the military services, and the longer-term research activities which provide a continuously developing Technological Base for these problem-solving activities.

In the fields of Chemistry, Microbiology, and Nutrition, the main scaffolding of the Technological Base was well developed by the 19th century, and current technological base efforts consist of creative selection of research questions that lead to future relevance. In the Behavioral Sciences, where the development of scientific techniques is more recent, the historical scaffolding is seldom present, and much of our basic knowledge must be obtained in tandem with problem-solving attempts. In the case of our group in Behavioral Sciences at Natick, continuing Technological Base includes three overlapping areas, shown in Figure 2, as part of Laboratory and Field Studies.

LABORATORY AND FIELD STUDIES

Taste/Flavor. Comparative studies of the chemical senses in animal models and man select those areas of research that apply to real foods and provide information on the relationship between sensory input, food choice, and acceptability. Examples are the relation between taste receptors and synthetic or natural sweeteners, and studies of mixtures, especially with real foods, e.g., adding mayonnaise to tuna salad, etc. Actual drinking behavior (sipping and swallowing) is analyzed in relation to taste stimulation and acceptability. These and other studies support our applied work in sensory evaluation and acceptance testing of foods, providing us with knowledge of appropriate controls for many significant variables (e.g., 1-8).

Methodology. This area overlaps all of our work in support services, our work in the laboratory, and in the field. This ranges from the development evaluation of new questionnaires and field surveys, to designing and comparing alternate methods for food acceptance testing, and in laboratory taste research, to designing and evaluating methods of measuring food choice, food intake, and studying the relation of actual food behavior to consumer preferences and food acceptance (e.g., 9-20).

Appetite/Food Choice. The mechanism of food intake and choice in animal models, and in man, are studied with emphasis on the role of taste and flavor in the systems controlling food acceptance. Studies range from work in animals, where background, environment, and ration quality and availability can be precisely controlled, to studies of eating behavior in man ranging from bite-to-bite analysis of eating behavior within a meal, to studies of meal patterns in a laboratory "cafeteria," to measurement of individual food habits in small sample groups in isolation, and under normal working conditions (e.g., 21-31). This work provides information on food habits which forms the basis of understanding the factors controlling Food Acceptance in the applied setting.

BEHAVIORAL SCIENCES SUPPORT ACTIVITIES

Sensory Evaluation. Laboratory and field Food Acceptance tests are carried out using Consumer Panels to actually taste and evaluate single food items, with major use by Food Technologists in Product Development. Each year we carry out several hundred Food Acceptance tests on individual items, drawing from a consumer panel of 500 Volunteer Laboratory personnel. In any one test, 30 "taste testers" will come to our Sensory Evaluation Laboratory and rate from one to four individual food items on the classic 9-point hedonic scale, from 1, dislike extremely, to 9, like extremely (32, 33). These tests provide information for food technologists to evaluate acceptability of food items in various phases of product development, and are also carried out on "pre-award" items that are being considered for purchase by the Armed Forces.

We also use the facilities of our Sensory Evaluation Laboratory for methodological studies as well as for the direct support work noted above. For example, we have compared the consistency of servicemen with our civilian panelists and have initiated a series of studies comparing our standard 9-point hedonic scale with more sophisticated magnitude estimation techniques where the panelists can use a wider range of numbers to express their likes and dislikes. In addition, we do an increasing amount of sensory evaluation in actual dining halls and simulated combat situations.

Food Preference Surveys. Standard paper and pencil questionnaires are administered to groups of servicemen in garrison and field situations, obtaining preference (9-point scale) and preferred frequency of serving (per month) from a list of food names. The major use is by food planners in menu design and food system modification (34).

Table 1 presents a sample page from one of the standard food preference surveys developed in our group.

The large amounts of data collected by this technique, developed by Army psychologists in the early 1950's (35) and extended and modified by our group over the past decade (34, 36-38) have proven very useful in menu planning and in the planning and modification of existing food service systems.

Table 2 shows one way in which the data collected from preference surveys can be used. By arranging the results of the 9-point scale in three categories on the horizontal axis, and the stated frequency of serving on the vertical axis, a matrix can be formed which is very useful. In this figure, which outlines data on entrees, we can see the extremes, a low preference cluster on the upper left, composed of sardines, liver, oysters, liverwurst. These get low hedonic ratings and are not wanted very often. In the lower right we can see a high preference cluster, that is highly preferred and wanted often. It is interesting to note

TABLE 1

Sample page from Standard Food Preference Survey.

Taken From: H.L. Meiselman, D. Waterman & L. Symington. Armed Forces Food Preferences. U.S. Army Natick Laboratory Technical Report 75-63-FSL, 1974.

Table 1

1	2	3	4	5	6	7	8	9
dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

	NEVER TRIED	HOW MUCH you like or dislike the food (1-9)	HOW OFTEN you want to eat the food in days per month (01-30)
001 Honeydew Melon			
002 Vealburger			
003 Tea			
004 Chili Macaroni			
005 Barbecued Beef Cubes			
006 Roast Turkey			
007 Blueberry Muffins			
008 Strawberry Shortcake			
009 Baking-Powder Biscuits			
010 Grape Juice			
011 Nut Bars			
012 Turnip Greens			
013 Celery & Carrot Sticks			
014 Boiled Pigs' Feet			
015 Grilled Minute Steak			
016 Hot Turkey Sandwich with Gravy			
017 Sliced Tomato Salad			
018 Braised Liver with Onions			
019 Tomato Juice			
020 Creamed Frozen Peas			
021 Mashed Rutabagos (Turnip)			
022 Fried Rice			
023 Corned Beef			
024 French Fried Carrots			
026 Egg Drop Soup			
026 Jellied Fruit Salad			
027 Apricot Pie			
028 Gingerbread			
029 Cheeseburger			
030 Apple Juice			
031 Sausage Links			
032 Banana Cake			
033 Turkey Club Sandwich			
034 Pineapple Upside Down Cake			
035 Frozen Lima Beans			
036 Grilled Bologna			
037 Oatmeal Cookies			
038 Skimmed Milk			
039 Pork Sausage Patties			
040 Italian Dressing			
041 Baked Fish			
042 Hot Reuben Sandwich			
043 French Toast			
044 Pizza			
045 Shrimp Creole			
046 Caesar Dressing			
047 Split Pea Soup			
048 Pepper Soda			
049 Ice Cream			
050 Simmered Sauerkraut			
051 Steamed Rice			
052 Buttered Noodles			
053 Raspberry Shortcake			
054 Swiss Steak			

TABLE 2

Matrix Showing Relationship Between Stated Preference on Hedonic Scale (Horizontal) and Preferred Frequency of Serving (Vertical).

Data From: H.L. Meiselman, W. Van Horne, B. Hasenzahl, & T. Wehrly. The 1971 Ft. Lewis Food Preference Survey. U.S. Army Natick Laboratory Technical Report 72-43-PR, 1972.

RELATIONSHIP BETWEEN PREFERENCE SCALES FOR EVENING MAIN DISHES

HEDONIC SCALE

	LOW	MODERATE	HIGH
Low	A. Sardines D. Liverwurst	D. Cervelot (c.c.)	
Moderate	A. Fried Oysters C. Beef Liver	A. Fish Shrimp Creole Breaded Shrimp Tuna Salad Seafood Platter Baked Tuna & Noodles Lobster Newburg Salmon B. Baked Macaroni & Cheese Lasagna C. Lamb Roast Polish Sausage Lamb Chops Veal Roast Spare Ribs & Sauerkraut Corned Beef BBQ Beef Cubes Veal Parmesan C. Veal Burger Breaded Veal Steaks Baked Stuffed Pork Sl. Swedish Meat Balls Pepper Steak Italian Sausage Chili Con Carne Chili Con Carne/Beans D. Bologna (c.c.) Frankfurter Salami (c.c.) Sloppy Joe** Turkey Club Sandwich Submarine Sandwich Luncheon Meat (c.c.) Ham (c.c.) Chicken Club Sandwich Turkey (c.c.) Meatball Submarine D. Tacos Western Sandwich Shredded Beef w/BBQ S. Hot Tamales	B. Pizza Spaghetti Ravioli Chili Macaroni C. Ham (canned) Sl. Roast Pork w/Gvy. Roast Pork Ham Pot Roast BBQ Spare Ribs Meat Loaf Cheeseburger Gr. Chse/Ham Sand. Hot Roast Bf. Sand. BLT Sandwich Hot Turkey Sand. /Gravy Grilled Cheese Turkey
High		A Lobster	C. Roast Beef Swiss Steak Grilled Steak Salisbury Steak Fried Chicken Chicken Turkey Sl/gr. D Hamburger Pizza

that the cluster of high preference/high serve items covers "short-order-items" typical of the popular group of items increasingly in demand in commercial "fast food" snack bars in this country (34).

Table 3 shows summary data from a recent survey covering samples from all of the U.S. Armed Forces (38). These data are averaged for an aggregate of 4,000 men and 12 test sites, from Army, Air Force, Navy, and Marine garrison feeding systems in the Continental United States to data collected on Naval vessels in port.

The higher (left) and lower (right) classes in this Figure refer to those items that are significantly different from the everage clase scores in quantitative statistical tests. Again note, the short-order items are highly preferred. It should be noted that the ranking comes from group averages, summaries of very large samples in which our intent has been to characterize the Armed Forces as a whole. However, close analysis shows that individual differences are present, and that analysis by subgroup provides helpful information for food planners.

The data on milk products in Table 3 verify the common observation that preferences are not always in accord with nutritional factors. In this case "taste" leads to selection of whole milk (with 50% of its calories as fat) over "skimmed milk" (2% as fat), buttermilk (2% as fat) or yogurt (31-50% as fat). The popularity of whole milk in young Americans is well known. Figure 3 shows an example of meesured intake of whole milk from a nutritional survey carried out on 100 Army troops for a 28-day period. Note that almost 40% of the total fat calories consumed came from milk. Thus, one could, theoretically, reduce overall animal fat intake from 40% to about 25% by simply substituting a non-fat drink for pasteurized milk. Could the present state-of-the-art in nutrition education modify preference for a single beverage on a large scale? This untapped area of food habits research provides unlimited opportunities for constructive and imaginative work.

Apropos of the question of individual differences raised above, we would have to be careful in generalizing these data on Americans to the European Armed Forces. Although, to my knowledge, there is no direct quantitative comparison available, European countries would most likely present a different pattern of acceptability for members of their Armed Forces, high on yogurt and low on whole milk.

Let us look briefly at two specific examples of analyzing individual differences from aggregate data on large groups. Table 4 shows such an analysis, listing those food consistently liked by Black members of our Armed Forces. The overall pattern follows the popular cuisine known as "soul food" in this country. If one were planning menus based upon aggregate data alone (Table 3), pork hocks and pickled pigs feet are low preference items. However, Table 4 shows them to be high preference items for Blacks. This information would be useful in cases where menu planning should take account of large sub-groups of servicemen rather than to cater to the aggregate alone.

TABLE 3

List of High and Low Preference Items for U.S. Servicemen.

Modified From: H.L. Meiselman, D. Waterman & L. Symington. Armed Forces Food Preferences. U.S. Army Natick Laboratory Technical Report 75-63-FSL, 1974.

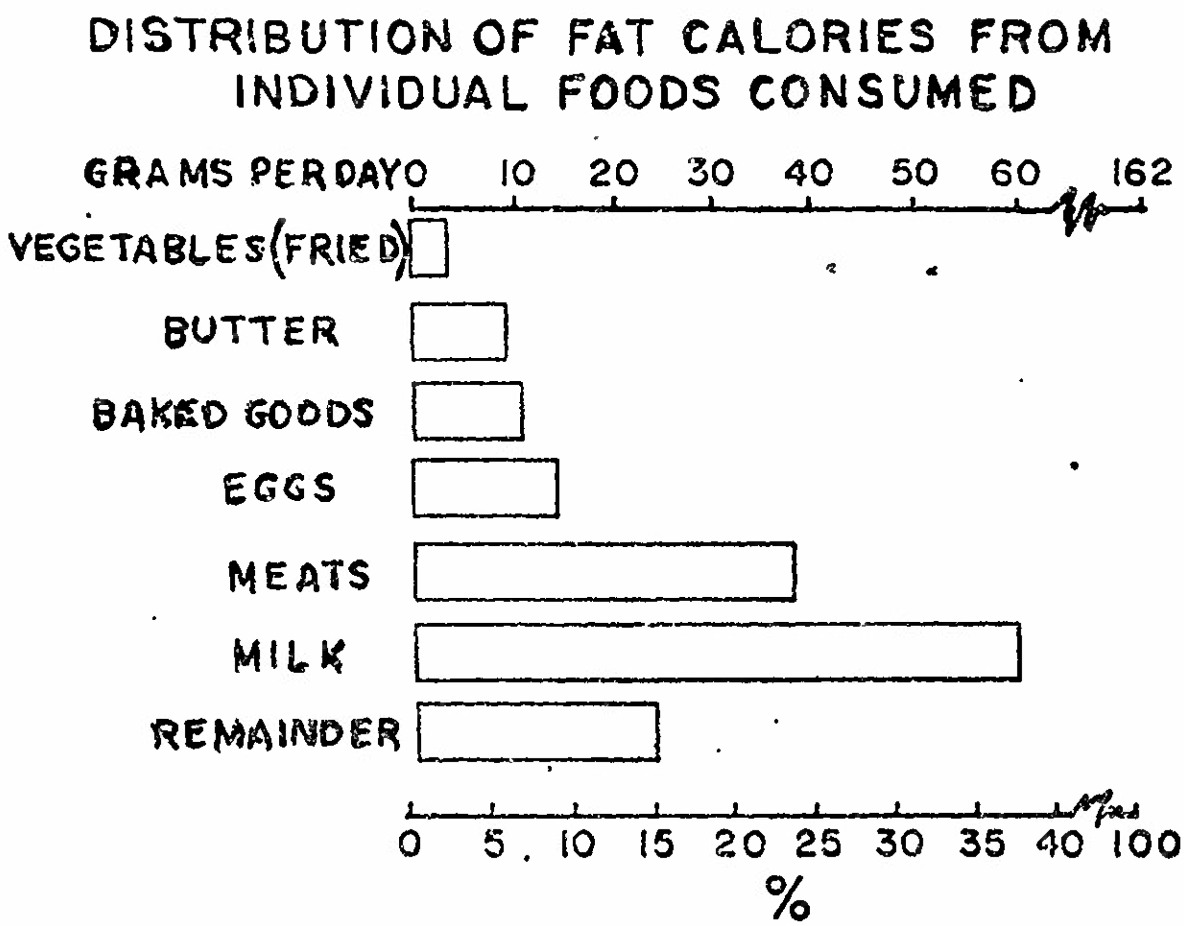
Table 3

FOOD CLASS	HIGH	LOW
Fish and Seafood	French Fried Shrimp Seafood Platter Lobster	Baked Fish Salmon Baked Tuna & Noodles
Meats	Roast Beef Swiss Steak Pot Roast Grilled Steak Grilled Min. Steak B B Q Spareribs Grilled Ham Baked Ham Italian Sausage Fried Chicken Baked Chicken Hot Turkey Sand. w/gravy Hot Roast Beef Sand. w/gravy	Grilled Lamb Chops Spareribs w/sauerkrt Corned Beef Pork Hocks Pickled Pigs Feet Sauerbraten
Stews & Extended Extended Meats	Lasagna Pizza Spaghetti w/Meat Sauce Spaghetti & Meat Balls Meatloaf Swedish Meatballs Salisbury Steak Beef Stew	Chicken Cacciatore Chili Macaroni Ham Loaf Vealburger Stuffed Cabbage Corn Beef Hash Stuffed Green Peppers Pork Chop Suey Sweet & Sour Pork Sukyaki Baked Tuna & Noodles
Short Order, Sandwiches	Hamburger Cheeseburger Ham Sandwich BLT Grilled Cheese Grilled Ham & Cheese Sloppy Joe Pizza	Frank, Cheese & Bacon Salami Sand. Bologna Sand. Hot Reuben Sand. Hot Pastrami Fishwich
Fresh Fruit	Oranges Apples	Plums Honeydew Melon Fruit Cup
Milk Products	Milk Ice Cream	Skimmed Milk Buttermilk Fruit-Flvd. Yogurt
Carbonated Beverages	Cola	Lo-cal Soda

Figure 3. Contribution of Milk Intake to Total Fat Ingestion in Soldiers Fed Ad Libitum for 28 Days.

Taken From: The Dietary Composition and Adequacy of the Food Consumed by Soldiers Under an Ad Libitum Regimen. U.S. Army Medical Nutrition Laboratory. Denver, Colorado. Report 184, July, 1956.

Figure 3



DISTRIBUTION OF FAT CALORIES FROM INDIVIDUAL FOODS CONSUMED
GRAMS PER DAY 0 10 20 30 40 50 60 162
VEGETABLES (FRIED)
BUTTER
BAKED GOODS
EGGS
MEATS
MILK
REMAINDER
0 5 10 15 20 25 30 35 40 100
%

TABLE 4

List of Food Entrees Which Blacks Significantly Preferred Over Whites in Stated Preference on A 9-Point Hedonic Scale, and on Preferred Frequency of Serving Per Month.

Taken From: H.L. Meiselman. The Role of Sweetness in the Food Preference of Young Adults. (In) J.M. Weiffenbach (Ed.). Taste and Development: The Genesis of Sweet Preference, Wash. D.C., Superintendent of Documents, U.S. Govt. Printing Office (In Press, 1976).

Table 4

ENTREES	HEDONIC		FREQUENCY		NOTES
	B	W	B	W	
barbecued beef cubes	6.56	6.03	10.03	6.95	
barbecued spareribs	7.65	6.68	15.31	9.41	WN-
boiled pigs' feet	6.64	3.49	10.09	3.20	BS+
braised liver w/onions	5.44	4.47	7.65	5.16	
chitterlings	7.13	3.59	12.78	4.04	WN-
fried fish	6.84	6.31	12.16	8.78	WN-
grilled bologna	5.57	4.90	8.34	5.97	
pepper steak	6.94	6.53	11.84	9.08	
pickled pigs' feet	6.54	4.25	11.88	4.92	BS+
pork chop suey	6.26	5.25	10.56	6.79	BS+
pork hocks	6.57	4.85	11.44	5.72	WN-
salmon	6.18	5.69	9.34	7.12	
sausage links	7.07	6.68	15.09	13.47	
stuffed cabbage	5.85	5.31	8.88	6.56	
tuna salad sandwich	6.72	6.36	11.80	9.35	

A final example of individual differences concerns the role of the geographic origin of servicemen, as shown in Figure 4. Members of the Armed Forces whose geographic origin is in the Southwestern United States show higher acceptability of hominy grits, a regional breakfast cereal, than those from other areas.

Consumer Opinion Surveys. The sensory evaluation and the consumer preference techniques discussed above focus on food items *per se*. The consumer opinion questionnaires we have used are designed to elicit information on factors in the acceptability of the food service system as a whole. Our logic in using these techniques was to get base-line data at a chosen food service facility, give this information to the Operations Research/Systems Analysis Office, after which we would retest the servicemen, to see if the changes in the system in fact reduced the complaints, increased attendance, etc. (39-44).

Table 5 shows a typical series of questions used in our consumer opinion surveys, and Table 6 summarizes the major factors measured with this technique which have been shown to be important in system acceptability and attendance. Table 7 shows the ranking between 5 food variables among the 14 factors selected as important and dining hall satisfaction. Although there are some differences between test sites, the food variables as a group are extremely important, with food quality topping the list.

Table 8 is an example of the analysis of a non-food irritant, "waiting in line", which we tried to validate by relating the stated importance of waiting (columns 3 & 4) to the actual reported delays. It is apparent that test sites reporting longer delays considered waiting as more important to attendance and general acceptance in the dining hall.

The above examples summarize some of the kinds of behavioral sciences techniques we use to obtain information on acceptability by using laboratory or field surveys and interviewing techniques, to obtain information from consumers on products, and about the system itself (Figure 2).

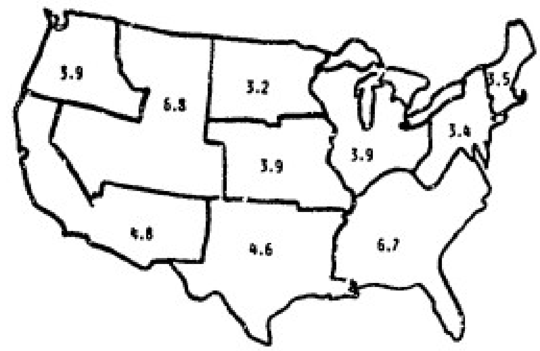
Menu Combinations/Choices. This is a new and still developing approach to food acceptability of actual meals, rather than single food items. It uses simple paper and pencil tests to gather data on combinations of meal items, on actual food choices, analyzing the data with complex computer models. This approach takes into account the role of monotony in cyclic menus, economic and nutritional constraints, etc. It is useful in conjunction with systems analysis approach to menu planning and food service system design (e.g., 45-48).

Human Factors Engineering. This area evaluates the design and operation of food service equipment, kitchen layout, dining hall environment, and traffic patterns, etc., to maximize compatability with human user, both food service staff, and the dining hall customer. The psychologist provides design guidance by working with design engineers early in the development cycle, and with Operations Research/Systems Analysis Office on the final Operational System as a whole, as well as helping to evaluate actual

Figure 4. Effect of Geographic Origin of Soldiers on Their Preference for Hominy Grits, a Breakfast Cereal Historically Popular in the Southeastern United States. Top, Stated Preference on 9-Point Hedonic Scale; Middle, Preferred Frequency of Serving per month; Bottom, Percentage of Sample Stating They Never Want this Item.

Taken From: H.L. Meiselman. Regional Differences and Consumers. Society for the Advancement of Food Service Research. p. 319-54, 1973.

Figure 4



HOMINY GRITS - MEAN HEDONIC

HOMINY GRITS - MEAN FREQUENCY/MONTH (BREAKFAST)

HOMINY GRITS - PERCENTAGE NEVER EAT

TABLE 5

Sample Page of Questions from a Consumer Opinion Survey.

Taken From: L.G. Branch, H.L. Meiselman, & L. Symington. A Consumer Evaluation of Air Force Food Service. U.S. Army Natick Laboratory Technical Report, 75-33-FSL, 1974.

Table 5

Answer the following questions for the regular meal only. Exclude the short order meal. Indicate "Not Appropriate" (8) if you have self-service and/or second helpings permitted.

a. What is your opinion about the amount of meat per serving:

Too Little			About Right			Too Much	NA
1	2	3	4	5	6	7	8

b. What is your opinion about the amount of starches per serving:

Too Little			About Right			Too Much	NA
1	2	3	4	5	6	7	8

c. What is your opinion about the amount of vegetables per serving

Too Little			About Right			Too Much	NA
1	2	3	4	5	6	7	8

d. What is your opinion about the amount of dessert per serving.

Too Little			About Right			Too Much	NA
1	2	3	4	5	6	7	8

Indicate your opinion about the ABILITY of the COOKS to prepare high quality meals in your dining facilities

Very Poor			Average			Excellent
1	2	3	4	5	6	7

Indicate your opinion about the ATTITUDES of the dining facility WORKERS to make your meal as pleasant as possible.

Very Poor			Average			Excellent
1	2	3	4	5	6	7

Indicate your opinion of the VARIETY of offerings at any particular WEEKDAY meal

	We need	Many More Choices	A Few More Choices	Choices Now Enough	Fewer Choices Acceptable
a.	For short order foods.	1	2	3	4
b.	For meats	1	2	3	4
c	For starches	1	2	3	4
d.	For vegetables.	1	2	3	4
e.	For salads.	1	2	3	4
f.	For beverages	1	2	3	4
g.	For desserts:	1	2	3	4

TABLE 6

List of Major Factors in Consumer Acceptability of Food Service Systems as a Whole.

Table 6

FACTORS IN CONSUMER OPINION OF FOOD SERVICE SYSTEMS

FOOD	FOOD SERVICE	ENVIRONMENT	SOCIAL
QUALITY	PERSONNEL	CONVENIENCE	EATING COMPANIONS
QUANTITY	SPEED OF SERVICE	PHYSICAL	ATMOSPHERE
VARIETY	HOURS OF OPERATION	DECOR	
	EXPENSE	MONOTONY	

TABLE 7

The Ranking of Five Food Variables Within a List of Fourteen Food Service Variables Tested at Eight Bases in the United States. AFB = Air Force Base; NAS = Naval Air Station; RIK is Air Force Designation (Rations in Kind); SIK is Army Designation (Subsistance in Kind); Low Numbers Refer to High Ranks.

Table 7

BASE	FOOD QUALITY	FOOD QUANTITY	WEEKDAY FOOD VARIETY	WEEKEND FOOD VARIETY	SHORT ORDER FOOD VARIETY
FORT LEE	3	6	5	7.5	2
FORT MYER	1	5	3	2	4
BOLLING AFB	1	7	3	2	5
TRAVIS AFB	1	8	3	2	5
MINOT AFB	1	4	5	3	7
HOMESTEAD AFB	1	4	3	2	7
SHAW AFB	7	6	9	10	8
ALAMEDA NAS	3	8.5	5	4	1

DATA ONLY FROM THOSE RECEIVING FREE FOOD (RIK,SIK)
RESPONSE SCALE FROM BAD PROBLEM TO GOOD ATTRACTION.

TABLE 8

Relation Between Reported Delay at Meals and the Stated Importance of Waiting in Line in Determining Dining Hall Attendance, and General Dining Hall Evaluation. See Table 7 for Key to Abbreviations.

TABLE 8

REPORTED DELAY IN SERVING LINES*

NAME OF BASE	DELAY AT HEADCOUNT (MINUTES) (1)	DELAY AT SERVING LINE (MINUTES) (2)	RANK OF 14 FACTORS FOR ATTENDANCE (3)	RANK OF 14 FACTORS FOR EVALUATION (4)
TRAVIS AFB	3.80	4.19	12	9
LORING AFB	3.52	4.73	9	8
HOMESTEAD AFB	4.65	5.45	7	6
ALAMEDA NAS	4.49	5.74	8	7
MINOT AFB	6.39	5.24	4.5	2
SHAW AFB		6.00	1	1
FORT LEE	11.96	8.23	1	1

*DATA REPORTED BY THOSE RECEIVING FREE FOOD (SIK OR RIK).

operation of items already in garrison and field setting. For example, in 1974, Natick psychologists were observers in the Reforger Exercise in Germany, with special emphasis on the operation of the mobile field kitchen, M-2 burner, etc.[1] One of the critical functions of human factors evaluation in actual field operations is to take into account the well-known discrepancies between the standard operating procedures for troop use, set up during the developmental cycle at laboratories like Natick, and then on-the-spot decisions of ingenious soldiers whose actual use of this equipment is dependent upon changing local conditions, etc. (49).

Food Service Workers. In this area, the psychologist measures the morale and attitudes of the food service worker to the system, with special emphasis on job satisfaction, and career plans, and the attitudes of the consumer to him. The relationship between the training and performance of the food service worker is evalueted to provide information for modification of job characteristics, etc. (e.g., 50, 51).

SECOND-ORDER EFFECTS OF FOOD SERVICE - A VIEW FOR THE FUTURE

In addition to providing research support and service to requirements generated by our current food service systems, the scientist also has the responsibility and the occasional opportunity to suggest new requirements and new points of view.

In this final section, we would like to extend our current point of view, which works with Food Service as a self-contained system, and visualize it from the point of view of the larger Military System of which it is a part.

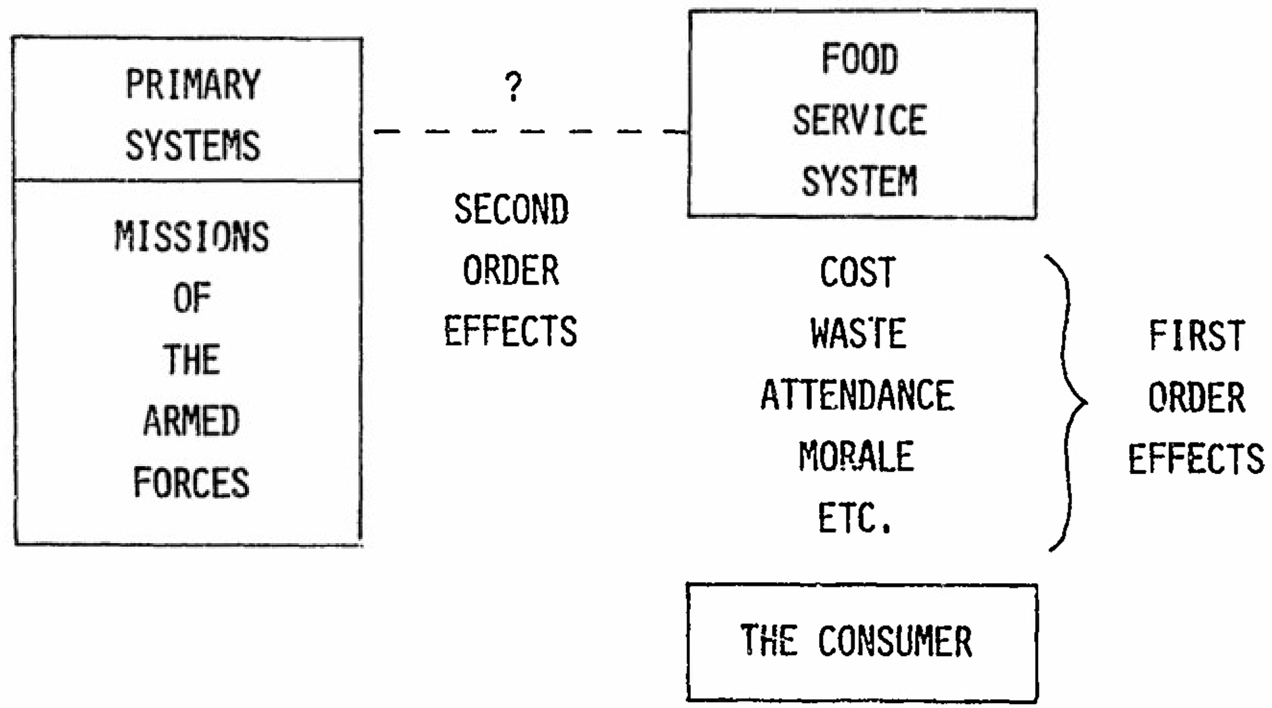
If the Armed Forces are considered as a whole, Food Service is primarily logistical; it provides a delivery system to supply edible food to the military consumer in much the same way that the gasoline delivery system supplies combustible fuel to trucks and tanks. This view has a long history in military systems, expressed, for example, in Napoleon's recognition that,"an Army marches on its stomach".

Historically, Natick's role in U.S. Military Food Service has been consistent with this theme. Our mission has been to develop Food Service Systems to deliver nutritious, acceptable food to the Armed Forces Consumer in garrison and field. Thus, we have continuously evaluated, modified, and improved food service with the goal of minimizing cost and waste, while maximizing attendance and morale within the Food Service System itself. In Figure 5 we have schematized this approach by defining the relation between the Consumer and the Food Service System as First

[1] In field studies such as Reforger, psychologists would also be obtaining information on Food Preferences and Consumer Opinion about the Food Service, etc.

Figure 5. Improvement in Food Service Systems Produces <u>First Order Effects</u> on the Consumer. Does Food Service Have Any <u>Second Order Effects</u> on the Primary Missions of the Armed Forces?

Figure 5


PRIMARY SYSTEMS
MISSIONS OF THE ARMED FORCES
?
SECOND ORDER EFFECTS
FOOD SERVICE SYSTEM
COST
WASTE
ATTENDANCE
MORALE
ETC.
FIRST ORDER EFFECTS
THE CONSUMER

Order Effects. With this as a starting point, we can now look at what we are doing from a broader point of view and ask whether there is any relation between food service and the major operational systems of the Armed Forces. We have labelled this relationship Second-Order Effects.

If the Food Service System does influence the Primary Operational Systems of the Armed Forces, these second-order effects have to be mediated by a human link, the Consumer, who is also a member of the Armed Forces. Figure 6 outlines the dual role of the soldier as Consumer, and as Member of the Armed Forces, performing his part in the operational system itself. Thus, we can ask whether the Consumer's increase in "morale" in the dining hall, which we measure before and after improving a Food Service System (First-Order Effect), generalizes to his morale and performance as clerk, driver, mechanic, or in his combat effectiveness as infantryman, after he leaves the dining hall (Second-Order Effects).

In the past, we have used all of our research and development resources to improve and evaluate food service in terms of first-order effects. Although many of us have made implicit assumptions that food service related increments in morale do indeed spin off to increase morale and performance in general, no one has ever studied this. If it can be shown that Food Service directly effects primary operational systems, this could be quite important.

Thus, the concept of second-order effects gives us an opportunity to begin to investigate this question, an increasingly important one in this country, as we attempt to maximize the efficiency and performance of our All-Volunteer Military Services in the face of decreasing financial and manpower resources.

Figure 7 outlines our view of how one would begin to investigate second-order effects, in terms of two kinds of measures. We have called the first System Variables which are statistically meaningful actuarial data potentially available in administrative records, and currently used by Command elements to evaluate productivity of operational systems. These data are focused on the group qua representative of the individual. The second class of measurements is what we have termed Person Variables, data based upon and focused on the individual qua representative of the group.

The approach outlined on Figure 7 could be used to look at positive effects of food service (e.g., increased morale and performance with a new dining facility, or highly acceptable field rations), possible negative effects of food service (e.g., the effect of 30-60 days of C-rations on Combat effectiveness), and the many cases where the second-order effects may be difficult to measure or are cancelled out by other confounding factors that also affect morale and performance, (e.g., increased enlistment rate can be due to family situation, financial factors, etc., as well as Food Service).

The latter cases will be especially challenging when one looks for effects developing over the long-term. For example, Figure 8 shows that

Figure 6. The Dual Role of the Soldier as the Critical Link Between the Food Service System and the Armed Forces Primary Mission.

Figure 6

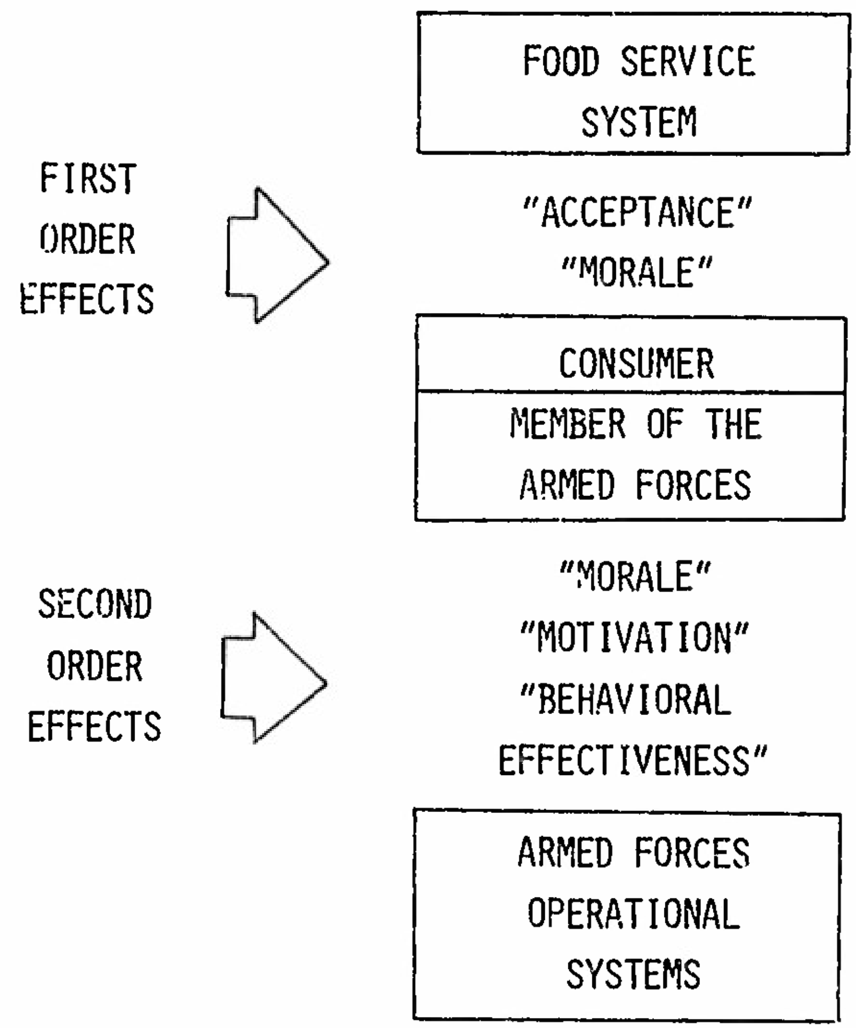
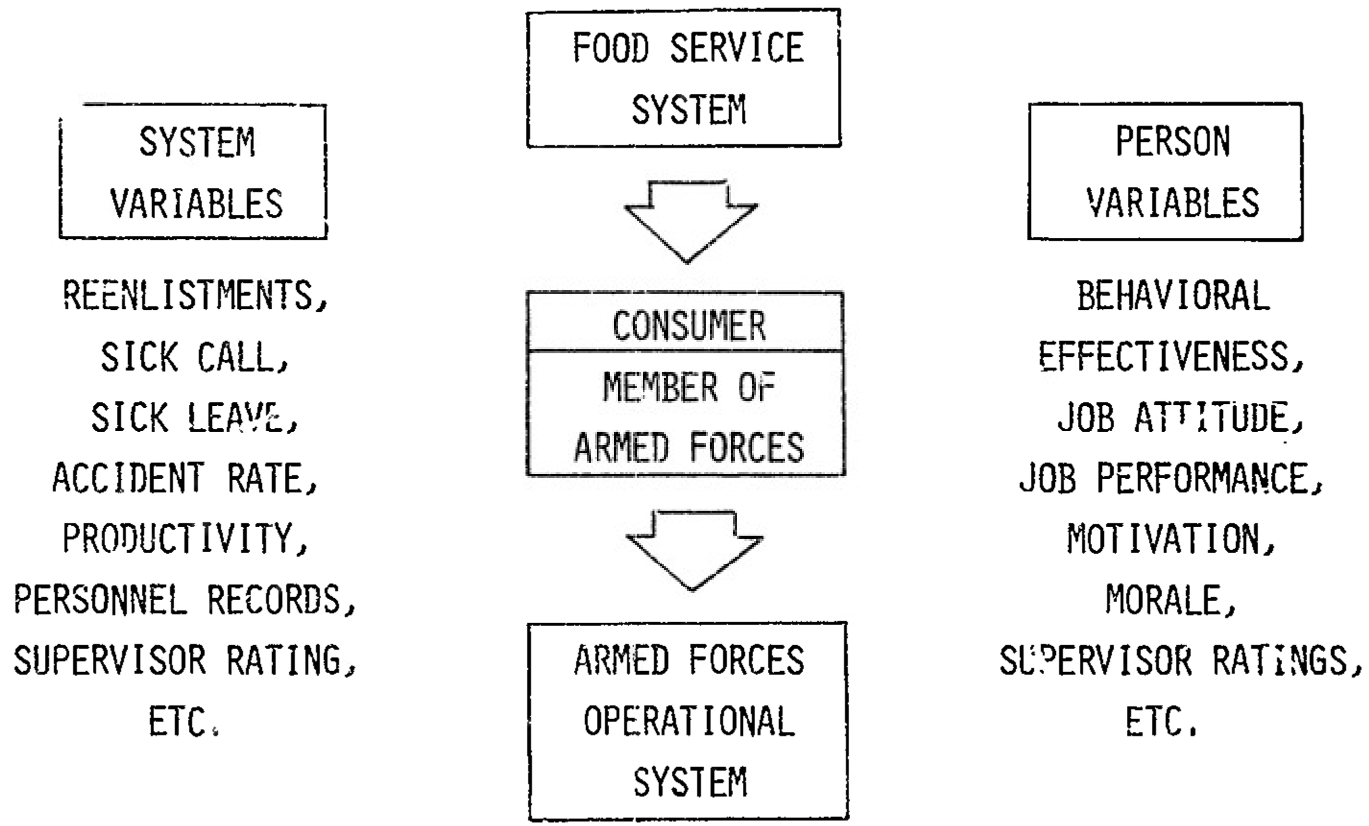

FOOD SERVICE SYSTEM
FIRST ORDER EFFECTS
"ACCEPTANCE"
"MORALE"
CONSUMER
MEMBER OF THE ARMED FORCES
SECOND ORDER EFFECTS
"MORALE"
"MOTIVATION"
"BEHAVIORAL EFFECTIVENESS"
ARMED FORCES OPERATIONAL SYSTEMS

Figure 7. Plan for Analysis of the Role of the Food Service System in the Primary Operational Systems of the Armed Forces. Operational Performance and Behavioral Effectiveness of The Consumer are Measured by Actual System Variables (left), and Individually Measured Person Variables (right).

Figure 7



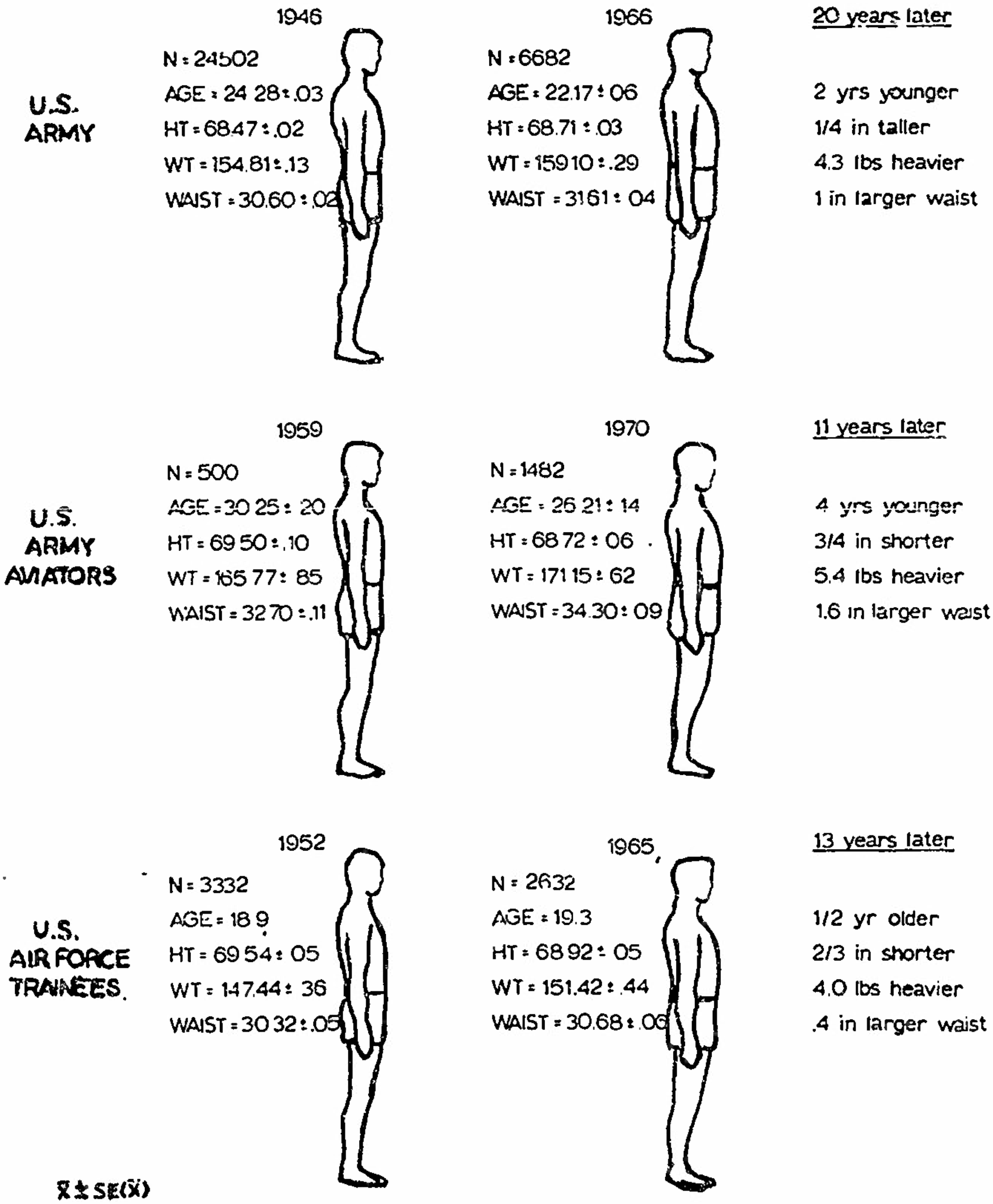
FOOD SERVICE SYSTEM
SYSTEM VARIABLES
REENLISTMENTS, SICK CALL, SICK LEAVE, ACCIDENT RATE, PRODUCTIVITY, PERSONNEL RECORDS, SUPERVISOR RATING, ETC.
CONSUMER
MEMBER OF ARMED FORCES
PERSON VARIABLES
BEHAVIORAL EFFECTIVENESS, JOB ATTITUDE, JOB PERFORMANCE, MOTIVATION, MORALE, SUPERVISOR RATINGS, ETC.
ARMED FORCES OPERATIONAL SYSTEM

Figure 8. Changes in Body Size in U.S. Servicemen Over Two Decades, Showing Increased Weight And Waiat Circumference.

Modified From: White, R.M., & Churchill, E. The Body Size of Soldiers. U.S. Army Anthropometry - 1966 U.S. Army Natick Laboratory, Technical Report 72-51-CE, Dec. 1971.

Figure 8

BODY SIZE OF SERVICEMEN



the American serviceman has become a few pounds heavier, and a little larger in the waist since World War II (51).[2]

Does this reflect the increasingly sedentary lifestyle in our over-fed, underexercised, and affluent society in which the food intake is consistently higher than current recommendations! in this country 3,400 kcal/day for military groups, and 3,000 kcal/day for civilian groups (52)?

Table 9 compares estimated food intake in dining halls from several large samples of troops with military recommended allowances. Discussing these and other nutritional surveys in the military, Canham points out that the results do show "evidence of biochemical and physical malnutrition... (and notes that)... the most significant condition of malnutrition that we observe is obesity (52a, p.85)."

Figure 9 shows the excess food intake in one group of enlisted men studied in detail in 1955 (53). These troops gained an average of 4.4 lbs. by overeating by as much as 1000 kcal/day over a 28-day test period on highly palatable freshly prepared rations. Table 10 shows that the smaller, lighter men in this group of 100 men could run faster, had a stronger grip, and a better circulatory response to exercises (54). In terms of our discussion, we would also ask if they were any different in morale and "behavioral effectiveness". Unfortunately there are no data available at present to answer this important question. Thus, the study of morale and behavioral effectiveness as a function of diet and pattern of intake could provide critical information in long term studies of second-order effects.

A final area of research that becomes relevant from this point of view concerns the effect of single meals on subsequent performance and behavioral effectiveness. One statistical study suggests that missed meals may be an important factor in aircraft accidents (55). What of the effect of a missed meal, or of "overstuffing" on subsequent performance in night operations, or on helicoptor flights, for example? Our Food Service System is currently based upon a 3-meal day. At present, the only decision in serving a midnight meal prior to a night operation is whether to define it as "breakfast", "dinner", or "snack." Although a soldier stuffing himself with alcohol prior to or during night operations is in serious trouble, he is completely free to miss a meal, or stuff himself at will, before going on duty, snacking candy while working, or any combination thereof. Does this influence behavioral effectiveness? When studies are carried out on questions of this type the results will have obvious practical import.

[2] These data were culled from a series of Anthropometric studies conducted in the Armed Forces starting in 1946. It should be noted that an Army Nutritional Survey carried out at Ft. Campbell, Kentucky, initially in the 1950's and repeated in 1967, showed a significant increase in height. Personal Communication, F. Consolazio.

TABLE 9

Examples of Army and Air Force Estimates of Dining Hall Food Consumption Data.

Modified From: J.E. Canham, Nutrient Intake and Nutritional Status of Modern Military Personnel. Research and Development Activities Report, 24: 81, 1972.

TABLE 9

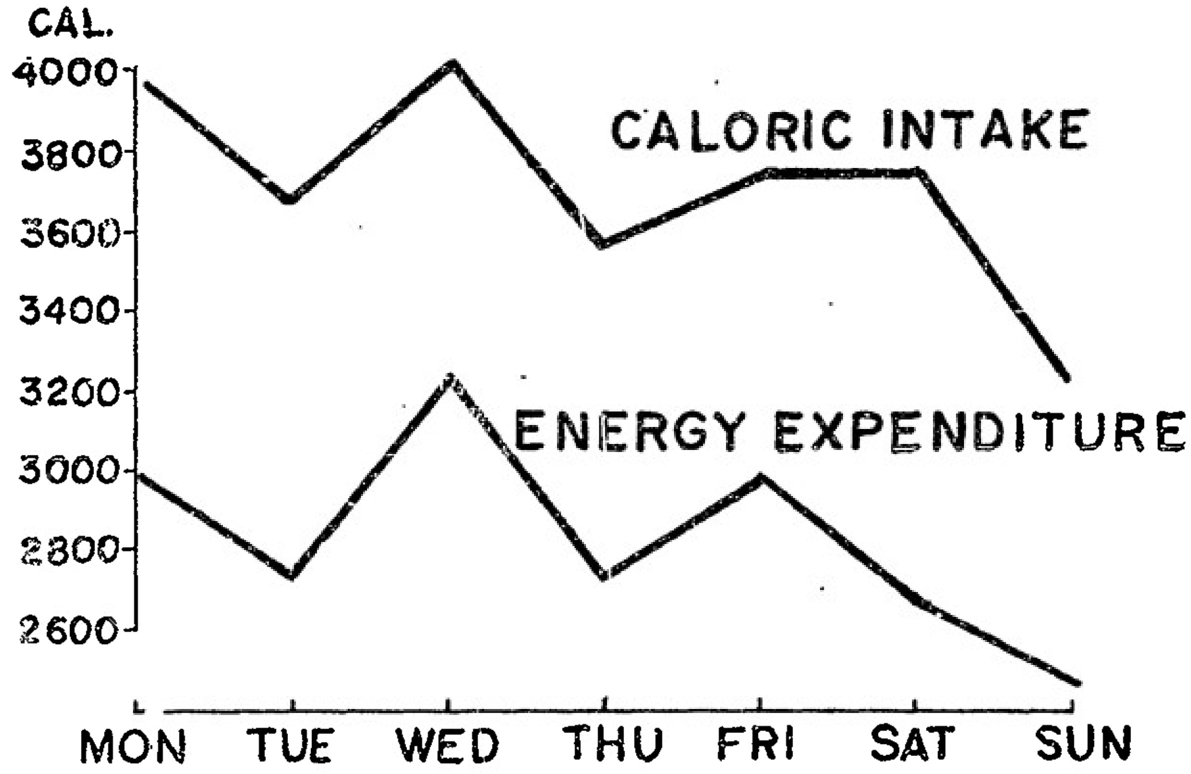
SOURCE OF DATA	RECOMMENDED ALLOWANCE AR 40 - 25	MASTER MENU 1968	FT. LEWIS[1] SPECIALTY HOUSE	FT. LEWIS[2] CFPF STANDARD PLUS SHORT ORDER	FT. LEWIS[2] SHORT ORDER HOUSE	FT. LEWIS CFPF	FT. LEWIS BASIC TRAINEES	59 DAY[3] INTAKES (4 ARMY POSTS)	WAC COMPANY
CALORIES	3400	4592	4254	3762	3648	3551	3589	3331	2108
FAT	< 40% (151)[4]	42% (214)	44% (207)	43% (181)	44% (177)	44% (175)	41% (162)	44% (161)	47% (111)
PROTEIN	12% (100)	14% (164)	16% (166)	15% (140)	15% (138)	15% (130)	14% (121)	15% (126)	15% (78)
		(CALCULATED)				(STANDARD MESS)	(STANDARD MESS)		(FT HUACHUC

1 CALCULATED FROM SINGLE MEAL DATA - ASSUMED STANDARD BREAKFAST AND LUNCH.
2 DERIVED AVERAGE INTAKES FROM DATA FROM TWO MEALS PERIODS EQUAL TO NORMAL SUPPER AND LATE EVENING MEAL.
3 FORT CARSON, HUACHUCA, CAMPBELL AND IRWIN.
4 (GRAMS)

Figure 9. Excess Food Intake Over Work Output of U.S. Troops Fed a Highly Palatable Freshly Prepared (Class A) Ad Libitum Rations for 28 days.

Taken From: The Dietary Composition and Adequacy of the Food Consumed by Soldiers Under an Ad Libitum Regimen. U.S. Army Medical Nutrition Laboratory, Denver, Colorado. Report 184, July, 1956.

Figure 9



CAL.
4000
3800
3600
3400
3200
3000
2800
2600
CALORIC INTAKE
ENERGY EXPENDITURE
MON
TUE
WED
THU
FRI
SAT
SUN

TABLE 10

Body Size an. Physical Performance Comparisons of Nine Best Men and the Overall Group Fed a Highly Palatable Freshly Prepared (Class A) Ad Libitum For 28 days.

Modified From: The Relation Between the Ad Libitum Food Intake, Physical Performance and Biochemical Changes in 100 Soldiers in a Training Company at Ft. Carson, 1955. U.S. Army Medical Nutrition Laboratory, Denver, Colorado. Report 214, Aug 1957.

Table 10

Measure	Average for Best 9	Average for Overall Group
Final wt. (lb.)	152.35	159.19
Height (in.)	67.41	69.9
Mean of five skinfolds (cm.)	0.913	1.354
Percent body fat	9.58	12.61
MNL step test	162.7	173.73
Hand dynometer (lb.)	117.48	110.42
Contest march (min.)	70.86	78.62
B.M.R. (Cal/hr.)	73.68	75.06

AN INTERDISCIPLINARY APPROACH

In sum, the above suggests that the Behavioral Sciences Food Program broaden its approach to the individual as consumer by beginning to study him as a performing member of the Armed Forces. Although the examples listed are all in behavioral sciences, a successful long-range approach to this problem must eventually include a multidisciplinary effort in which Natick psychologists interact with systems analysts, nutritionists, and physiologists.[3]

For example, analysis of the system variables shown in Figure 7 should proceed with psychologists collaborating with systems analysts to evaluate performance of Armed Forces Operational Systems from this point of view. A current study at Natick fits this paradigm nicely. Systems analysts at Natick have recently introduced a modular snack bar at an Air Force Base. This fast food facility has been very successful in increasing consumer participation (56). Natick behavioral scientists are following this up by studying food habits and attitudes of troops with high and low attendance at this facility (57). We now plan to return to this Air Base to take a look at system variable changes (e.g., flight maintenance, accident rate, etc.) in collaboration with systems analysts, as well as to initiate our own studies on person variables (Figure 7).

Other interdisciplinary opportunities are suggested by Figure 10, which schematizes the role of food preferences and food habits in Health, Performance, and Behavioral Effectiveness. Although this figure was constructed to reflect the problem from the point of view of behavioral science, it should be noted that two unlisted critical factors would be Exercise Patterns (Physiology) which combine with Food Habits (Psychology) to determine the state of Energy/Nutrient Balance (Nutrition). It is interesting to note that the behavioral scientist comes into the picture at the beginning and at the end, studying (a) food acceptance, (b) food habits as they influence the nutrient choices and intake of the individual, and (c) the consequences of under- or over-eating on behavioral effectiveness.

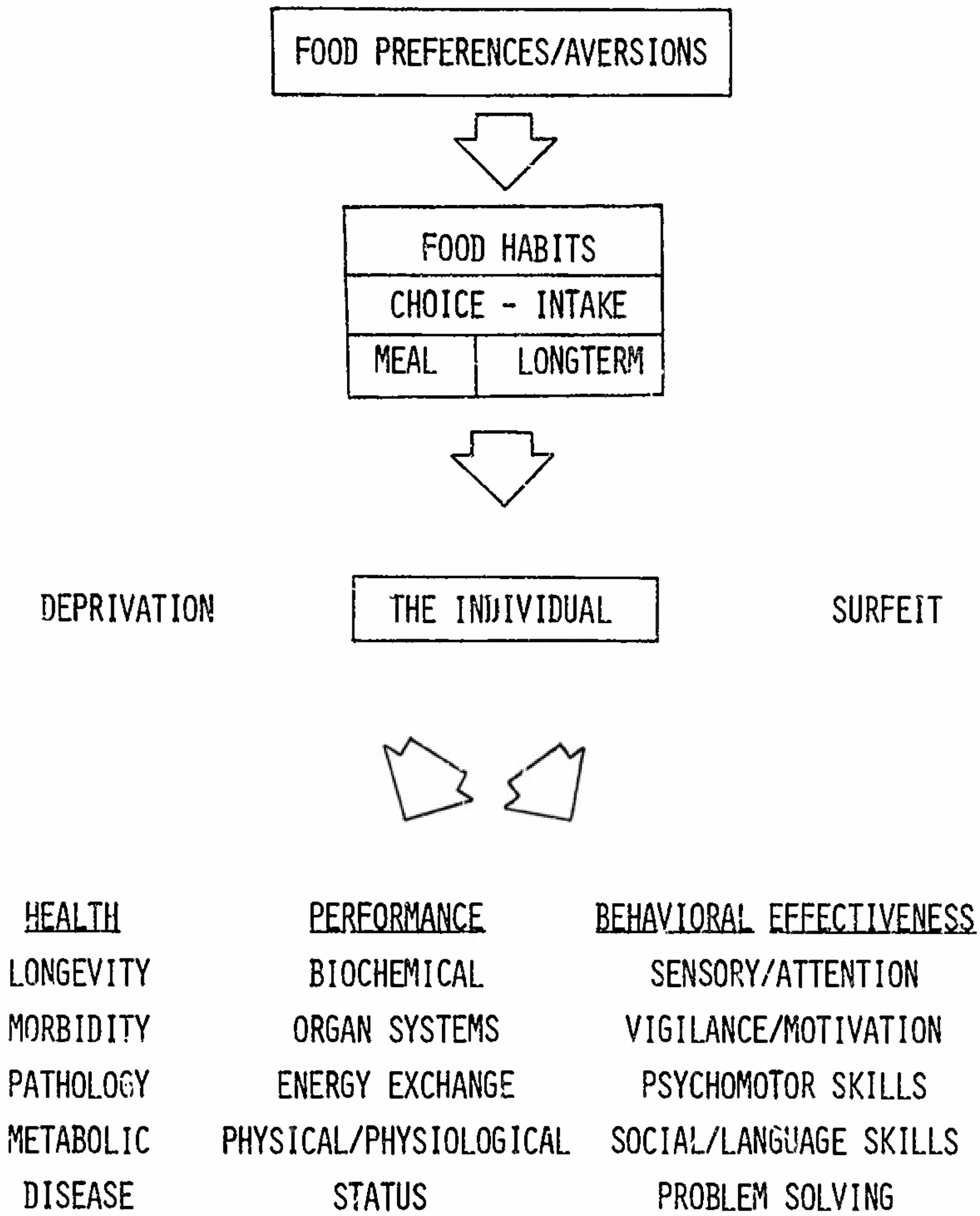
Why Study Behavioral Effectiveness? Most of the current work on the effect of food habits on the individual is on the extremes of deprivation or surfeit, ranging from clinical deficiencies in nutrients and calories to clinical obesity. Here the effects on health, and performance of the major biological systems are well documented, and follow the framework of medicine and nutrition.

---

[3] Interdisciplinary work must always overcome professional inertia as well as organizational and geographic distance. In this case, most of Behavioral Sciences and Systems Analysis is at Natick, Mass., under the Army Materiel Command, while most of the Nutritionists and Physiologists are at Letterman Army Institute of Research, San Francisco, Calif., under The Office of The Surgeon General

Figure 10. Schema of the Role of Food Habits in the Health, Performance, and Behavioral Effectiveness of the Individual.

Figure 10


FOOD PREFERENCES/AVERSIONS
FOOD HABITS
CHOICE - INTAKE
MEAL
LONGTERM
DEPRIVATION
THE INDIVIDUAL
SURFEIT
HEALTH
LONGEVITY
MORBIDITY
PATHOLOGY
METABOLIC
DISEASE
PERFORMANCE
BIOCHEMICAL
ORGAN SYSTEMS
ENERGY EXCHANGE
PHYSICAL/PHYSIOLOGICAL
STATUS
BEHAVIORAL EFFECTIVENESS
SENSORY/ATTENTION
VIGILANCE/MOTIVATION
PSYCHOMOTOR SKILLS
SOCIAL/LANGUAGE SKILLS
PROBLEM SOLVING

We have added the category of behavioral effectiveness to apply to the large majority of cases that cannot be classified in terms of classical deprivation or surfeit. In developing countries, they would fall into the overworked, underfed category. In highly developed Western countries, they are the overfed, underexercised majority that have been well recognized for decades. Note Figures 3, 8, and 9 and Tables 2, 3, 9, and 10 in the case of military groups. Research in the health and performance of the majority has been minimal, and non-existent in the case of behavioral effectiveness. This is unfortunate for this is becoming a problem of increasing importance in Western Armed Forces, a problem stated quite clearly almost two decades ago by a group of far sighted scientists working on "Nutrition and Performance" on emergency rations.

> "The general trend in military operations is unmistakably characterized by a shift from hard physical work to light work. Methodologically...this means a shift from the study of cardiovascular and respiratory functions...to motor skills and most importantly to the subtle functions of the central nervous system underlying "Awareness"... which at present elude measurement. (Keys, Taylor, and Brozek, 1958, 58).

Although the last phrase is disarmingly vague, they have anticipated our point perfectly. In the terms of Figure 10, they are stating the need to shift from the study of performance to the study of behavioral effectiveness. Nothing has been done in this area since these authors raised the iseue in 1958.

Conditions of sedentary life in the military have continued to grow, and in recent years budget tightening has increased pressure to minimize manpower and costs. In this context, our discussion of second-order effects suggests that a new program to seriously attack these issues could pay major dividends in understanding and improving performance of many major operational systems in the Armed Forces.

REFERENCES

1. Bartoshuk, L.M.,G.P. Dateo, D.J. Vandenbelt, R.L. Buttrick, and L. Long, Jr., Effects of Gymnema sylvestre and Synsepalum dulcificum on taste in man, In: Olfaction and Taste III, edited by C. Pfaffman, New York: Rockefeller Univ. Press, 1969, 436-444.

2. Meiselman, H.L. and B.P. Halpern, Effects of Gymnema sylvestre on complex tastes elicited by amino acids and sucrose, Physiol. Behav., 5:1379-1384, 1970.

3. Meiselman, H.L., Human taste perception, CRC Critical Reviews in Food Technology, 89-119, April 1972.

4. Moskowitz, H.R., Perceptual attributes of the taste of sugars, J. Food Sci., 37: 624-626, 1972.

5. Moskowitz, H.R., Effects of solution temperature on taste intensity in humans, Physiol. Behav., 10:289-292, 1973.

6. Bartoshuk, L.M., R.L. Gentile, H.R. Moskowitz, and H.L. Meiselman, Sweet taste induced by miracle fruit (Synsepalum dulcificum), Physiol. Behav., 12:449-456, 1974.

7. von Sydow, E., H. Moskowitz, H. Jacobs, and H. Meiselman, Odor - taste interaction in fruit juices, Lebensm.-Wiss. u.Technol., 7:18-24, 1974.

8. Segars, R.A., H.A. Nordstrom, and J.G. Kapsalis, Textural characteristics of beef muscles, J. Texture Studies, 5:283-297, 1974.

9. Meiselman, H.L., Effect of presentation procedure on taste intensity functions, Percept. Psychophys., 10(1):15-18, 1971.

10. Meiselman, H.L., H.E. Bose, and W.F. Nykvist, Magnitude production and magnitude estimation of taste intensity, Percept. Psychophys., 12(2B): 249-252, 1972.

11. Meiselman, H.L., H.E. Bose, and W.E. Nykvist, Effect of flow rate on taste intensity responses in humans, Physiol. Behav., 9: 35-38, 1972.

12. Moskowitz, H.R., R.A. Kluter, J. Westerling, and H.L. Jacobs, Sugar sweetness and pleasantness: evidence for different psychological laws, Science, 184:583-585, 1974.

13. Moskowitz, H.R., Combination rules for judgments of odor quality difference, J. Agr. Food Chem. , 22(5), 740-743, 1974.

14. Moskowitz, H.R., R.A. Segars, J.G. Kapsalis, and R.A. Kluter, Sensory ratio scales relating hardness and crunchiness to mechanical properties of space cubes, J. Food Sci., 39: 200-202, 1974.

15. Meiselman, H.L., Effect of response task on taste adaptation, Percept. Psychophys., 17(6): 591-595, 1975.

16. Moskowitz, H.R. and J.L. Sidel, Magnicude and hedonic scales of food acceptability, J. Food Sci.,36: 677-680, 1971.

17. Moskowitz, H.R., A. Dravnieks, W.S. Cain, and A. Turk, Standardized procedure for expressing odor intensity, Chem. Sens. Flav., 1: 235-237, 1974.

18. Branch, L.C., An evaluation of common predictors of consumer acceptance, U.S. Army Natick Labs Tech. Report 73-42-PR, April 1973.

19. Waterman, D., H. Meiselman, L. Branch, and M. Taylor, The 1972 Westover Air Force Base food preference survey and reliability study, U.S. Army Natick Labs Tech. Report 75-25-FSL, February 1974.

20. Branch, L.C., The validity of information from self-selected samples: the passive feedback system, U.S. Army Natick Development Center Tech. Report 75-106-FSL, January 1975.

21. Jacobs, H.L., Sensory and metabolic regulation of food intake: thoughts on a dual system regulated by energy balance, Proc. Seventh Internat. Cong. of Nutr., 2: 17-29, 1966.

22. Jacobs, H.L. and K.N Sharma, Taste versus calories: sensory and metabolic signals in the control of food intake, Ann. N.Y. Acad. Sci., 157(2): 1084-1125, 1969.

23. Jacobs, H.L., Biocontrol systems in food intake, Biomechanics, 81-93, 1969.

24. Morgane, P.J. and H.L. Jacobs, Hunger and satiety, World Rev. Nutr. Diet., 10:100-213, 1969.

25. Rodier, W.I., W.C. Wetsel, H.L. Jacobs, R.C. Craeber, H.R. Moskowitz, T.J.E. Reed, and D. Waterman, The acceptability of whey-soy mix as a supplementary food for pre-school children in developing countries, U.S. Army Natick Labs Tech. Report 74-20-PR, December 1973.

26. Smutz, E.R., H.L. Jacobs, D. Waterman, amd M. Caldwell, Small sample studies of food habits: I. The relationship between food preference and food choice in Naval enlisted personnel at the Naval Construction Battalion Center, Davisville, Rhode Island, U.S. Army Natick Labs Tech. Report 75-52-FSL, October 1974.

27. The beverage made to order, The Farm Index, 19-20, March 1974.

28. The beverage made to order, Comments by The Honorable Hubert Humphrey, Congressional Record, S8114, May 15, 1974.

29. Bartoshuk, L.M., H.L. Jacobs, T.L. Nichols, L.A. Hoff, and J.J. Ryckman, Taste rejection of nonnutritive sweeteners in cats, J. Comp. Physiol. Psych., 89(8), 971-975, 1975.

30. Engineering "milk", Engineered Foods, 7-9, October 1975.

31. Moskowitz, H.R., K.N. Sharma, V. Kumraiah, H.L. Jacobs, and S.D. Sharma, Cross cultural differences in simple taste preferences, Science, 190: 1217-1218, 1975.

32. Jones, L.V., D.R. Peryam, and L.L. Thurstone, Development of a scale for measuring soldier's food preferences, Food Res., 20: 512-520, 1955.

33. Peryam, D.R. and F.J. Pilgrim, Hedonic scale method of measuring food preferences, Food Technol., 11(9); Supplement, 9-14, 1957.

34. Meiselman, H.L., W. Van Horne, B. Hazenzahl, and T. Wehrly, The 1971 Ft. Lewis food preference survey, U.S. Army Natick Labs Tech. Report 72-43-PR, January 1972.

35. Peryam, D.R., B.W. Polemis, J.M. Kamen, J. Eindhoven, and F.J. Pilgrim, Food preferences of men in the U.S. Armed Forces, QM Food and Container Institute, 1-160, 1960.

36. Kamen, J.M., D.B. Peryam, D.R. Peryam, and B.J. Kroll, Analysis of U.S. Army preference survey (1963), Peryam and Kroll Research Corporation, Chicago, Ill., QM Tech. Report 67-15-PR, May 1967.

37. Moskowitz, H.R., T.L. Nichols, H.L. Meiselman, and J.L. Sidel, Food preferences of military men, 1967, U.S. Army Natick Labs Tech. Report 72-70-PR, May 1972.

38. Meiselman, H.L., D. Waterman, and L.E. Symington, Armed Forces food preferences, U.S. Army Natick Development Center Tech. Report 75-63-FSL, December 1974.

39. Branch, L.G. and H.L. Meiselman, Consumer reaction to the Fort Lewis CAFe system, U.S. Army Natick Labs Tech. Report TR-72-64-PR, May 1972.

40. Branch, L.G. and H.L. Meiselman, Consumer reaction to the Fort Lewis CAFe system: a follow-up, U.S. Army Natick Labs Tech. Report TR-73-36-PR, March 1973.

41. Branch, L.G. and H.L. Meiselman, The consumer's opinions of the food service system: the 1973 Travis Air Force Base survey, U.S. Army Natick Labs Tech. Report 73-52-PR, May 1973.

42. Branch, L.G., D. Waterman, L.E. Symington, and H.L. Meiselman, The consumer's opinions of the food service system: the 1973 Fort Lee survey, U.S. Army Natick Labs Tech. Report 74-49-PR, May 1974.

43. Branch, L.G., L.E. Symington, and H.L. Meiselman, The consumer's opinions of the food service system: the 1973 Minot Air Force Base survey, U.S. Army Natick Labs Tech. Report 74-7-PR, June 1973.

44. Branch, L.G., H.L. Meiselman, and L.E. Symington, A consumer evaluation of Air Force food service, U.S. Army Natick Labs Tech. Report 75-22-FSL, July 1974.

45. Rogozenski, J.E., Jr., A computer system for menu evaluation and related applications, U.S. Army Natick Labs Tech. Report 75-50-OR-SA, November 1974.

46. Moskowitz, H.R., J.E. Rogozenski, P.M. Walsh, and M.A. Wall, Quantitetive evsluation of menu preferences, unpublished manuscript, Food Sciences Lab, U.S. Army Natick Labs, Nstick, MA., 1975.

47. Moskowitz, H.R., J. Rogozenski, and L.E. Klarman, Time preference relations for menu items, unpublished manuscript, Food Sciences Lab, U.S. Army Natick Labs, Natick, MA., 1975.

48. Moskowitz, H.R., L.E. Klarman, and T. Wehrly, Food compatibilities and menu planning, unpublished manuscript, Food Science Lab, U.S. Army Natick Labs, Natick, MA., 1975.

49. Meiselman, H.L., L.E. Symington, E.R. Smutz, H.R. Moskowitz, T.L. Nichols, and F.T. Eggemeier, Field feeding: behavioral sciences studies, U.S. Army Natick Development Center Tech. Report 76-3-FSL, January 1975.

50. Symington, L.E. and H.L. Meiselman, The food service worker and the Travis Air Force Base experimental food system: worker opinion and job satisfaction, U.S. Army Natick Development Center Tech. Report 75-94-FSL, April 1975.

51. White, R.M. and E. Churchill, The body size of soldiers, U.S. Army anthropometry - 1966, U.S. Army Natick Labs Tech. Report 72-51-CE, December 1971.

52. Sauberlich, H.E. and J.E. Canham, Establishment and assessment of certain U.S. military nutrient requirements (this volume.).

52a. Csnham, J.E., Nutrient Intske snd Nutritional Status of Modern Military Personnel, Activities Report, Resesrch and Development Associstes, 24:81, 1972

53. The Dietsry composition and sdequacy of the food consumbed by soldiers under sn sd libitum regimen, U.S. Army Medical Nutrition Lsb, Denver, Colorado, Report 184, July 1956.

54. The relation between th_ ad libitum food intake, body composition, physical performance and biochemical changes in 100 soldiers in a training company at Fort Carson - 1955, U.S. Army Medical Nutrition Lab, Denver, Colorado, Report 214, August 1957.

55. Petit, P.E., W.T. Wilson, and T.N. Georges, Missed meals, U.S. Navy Medicine, 59: 44, 1972.

56. Hertwick, G., R.L. Busted, D.P. Leitch, M.M. Davis, J.R. Wetmiller, and T.T. Mattus, Experimental evaluation of the modular fast food facility at Travis AFB, U.S. Army Natick Labs Tech. Report 74-54-OR-SA, May 1974.

57. Shutz, H.G., Consumer behavior studies of modular fast food service operations at Travis Force Base, Part I. Consumer behavior of users, Part II.Consumer behavior and nutrient intake of a selected group of users, Consultant's Report to Behavioral Sciences Division, Food Science Lab, U.S. Army Natick Labs, January 1976.

58. Keys, A., H.L. Taylor, and J. Brozek, Nutrition and performance capacity, Project No. 7-84-12-011, Contract No. DA 44-109-QM-1526. File No. N-1125, Report No. 13 (final). Period 1 June, 1953 through 31 May, 1958. (Univ. of Minnesota, Lab. of Physiological Hygiene). 110-111.

SESSION IV -- REVIEW AND SPECIAL PROBLEMS

Chairman: Dr. Edward E. Anderson
Special Assistant, Dept. of Defense Food Research & Development Program
US Army Natick Research & Development Command
Natick, MA

Systems Analysis Studies of Combat Feeding	Dr. Robert S. Smith U.S.A.
War Research Food Stocks for the Federal Armed Forces - Problems Related to Foodstuffs & Packing Technologist	Ministerialrat Erich Pohl W. Germany
Insuring the Microbiological Safety of Military Feeding Systems	Drs. D. Rowley; G. Silverman and Mr. Edmund M. Powers U.S.A.
Latest Developments in Food Compression	Dr. Donald E. Westcott U.S.A.

SYSTEMS ANALYSIS STUDIES OF COMBAT FEEDING

by

Dr. R. S. Smith

Third International Meeting

Foods for the Armed Forces

17 October 1975

SYSTEMS ANALYSIS STUDIES OF COMBAT FEEDING

No discussion on combat feeding would be complete without a brief history of the subject and the events leading to this analysis. The current method of feeding troops hot meals in the United States Army is based on the concept of small unit level kitchens which are organic to each company. This concept, which can be traced back to the Revolutionary War, is based on the fact that the company is the basic administrative, social, and tactical unit within the Army. By contrast, the Marine Corps method is based on battalion level feeding in groups of 800-1000 troops. The equipment used in the current field feeding systems for both the Army and Marine Corps was designed in 1937. Over the years, it has undergone improvements but remains essentially the same in configuration. During the past decade, two R&D programs yielded new Mobile Kitchens for the Army using state-of-the-art equipment; these were the SPEED Kitchen, which was all electric and used micro-wave energy, and the Modular Mobile Kitchen, which utilized convection ovens heated by liquid fuels. However, testing by the Army Test and Evaluation Command against the standard M-1959 Kitchen revealed that neither of these developmental kitchens provided any significant improvements in terms of food quality or savings in manpower when cooking a modified "A" ration. I think it important here to elaborate what constitutes an "A" ration. This (Vu-graph No. 1) shows the food components of a typical Army or Marine Corps "A" ration of today. As you can see, we make a concerted effort to provide a type of meal which is very similar to that which the soldier is normally accustomed to in a garrison environment. In comparison with the menus of the vast majority of other Armies in the world today, our "A" ration field menu can best be described as complex. This complexity creates a requirement for additional equipment which must be available to food service personnel in order to provide the types of food desired by our customers.

In 1971, another new field kitchen was conceived which is trailer mounted and equipped with conventional ranges along with several new items of equipment intended to make the company sized kitchen highly mobile and more efficient. This new kitchen called the Mobile Kitchen Trailer (MKT) has been successfully tested by the Army and typed classified "Standard A". An initial production test of 200 kitchens is planned for early next year. The Marine Corps is also evaluating the MKT to determine its effectiveness at feeding large groups of 600-800 men.

With that as a background let me bring you up to date on our systems analysis study which we are conducting for both the Army and Marine Corps. The objectives of this study are: (Vu-graph No. 2)

1. To identify potential areas in the present system where significant reductions in food service personnel can be achieved in the short term.

2. To define a totally new system, using the latest state-of-the-art technology, for the 1985-1990 time frame which achieves the maximum possible reduction in food service personnel.

From these objectives, it is obvious that the major thrust of this project is directed towards personnel savings. This is due to our current trend of skyrocketing labor costs. For example, an E-5 cook in 1962 was paid $3700 dollars in direct wages as compared to $9584 for his 1975 counterpart. When combined with other costs this figure is increased to $13,548 (Vu-graph No. 3). This increase in labor costs, coupled with increased pressure to reduce spending by improving the "teeth-to-tail ratio" has resulted in a requirement to reevaluate field feeding to determine the potential for achieving manpower savings through consolidation of company level kitchens.

Before analyzing new systems, it was necessary to define the present system in terms of its cost and performance characteristics. The food service manpower requirements for a typical Army division are shown in the next vu-graph (Vu-graph No. 4). Approximately 6.5 percent of the total division strength of 16,574 personnel are required to operate the 115 company level kitchen in the present system. As for operating costs, a typical Army division requires an annual budget of 33 million dollars to feed its troops in a European theater. These costs are categorized into the following elements (Vu-graph No. 5). When combined with food, transportation and other costs, this amount to an average of $5.49 daily for three meals. By contrast, (Vu-graph No. 6), the operating cost of the Marine Corps system is significantly less, $4.86 per man per day principally due to the economies of scale associated with feeding at the battalion level. As a result, there are only 23 field kitchens in a typical Marine Corps Division as compared to 115 in the Army division.

At present, we are concentrating on manpower savings with the existing system since this system will be with us for at least another five years. In this conte . we recently completed an analysis of the potential for manpower savings that could be achieved with a limited consolidation of the Armys' company size kitchens. The results showed that consolidation is feasible, reducing the number of kitchens in a typical division from 115 to 50. It is important to note that our plan for consolidation is based on unit mission and battlefield location. Therefore, it is better described as a "variable" consolidation with kitchen capacities ranging from the company level (163 customers) to the battalion level (988 customers). The benefits which would be incurred through adoption of our plan for consolidation for a typical division would be (Vu-graph No. 7):

1. A 40% reduction in food service personnel.

2. A 58% reduction in kitchen attendants (KP's).

3. A savings of $5.5 million annually in operating costs.

I should point out that not all the savings in KP's is due to consolidation since some of the savings in KP's is due to the use of disposable trays and utensils.

The manpower savings achieved by consolidation are the direct result of increased worker productivity which we define as the number of meals served per manhour worked. This next slide (Vu-graph No. 8) shows the relationship between productivity and the kitchen capacity. The Armys' present system, with all company level operations, is 3.9 meals per manhour. It is important to note here that the productivity curve starts to level out at about the 1000-man level. From this we can conclude that there are no advantages regarding increased productivity for consolidations above the 1000-man level due to equipment constraints associated with the present system. If we project these savings to include the present 13 division Army, a total cost reduction of some 77 million dollars will be achieved annually. In terms of personnel, this would amount to 6,330 cooks and KP's who would no longer be required.

Clearly, any decision by the Army to consolidate its field feeding system will have far reaching implications. We, therefore, feel that prior to making any decisions, the concept should be subjected to validation and verification of performance and manpower savings by means of field feeding experiments. In this connection, we recently conducted an experiment in consolidated feeding with units of the Massachusetts National Guard undergoing their annual training. The objectives of this experiment were: (Vu-graph No. 9)

1. Determine the personnel savings potential of a battalion field kitchen.

2. Determine the effect of disposable tray service on kitchen attendant/logistical requirements.

3. Determine the equipment and shelter requirements of a battalion field kitchen.

4. Assess consumer acceptability of food prepared in the battalion kitchen as compared to the company kitchen.

I would now like to show you a series of slides which highlight some of the more interesting aspects of this experiment. (Show series of 10 slides).

By virtue of this experiment, we gained a wealth of information concerning the performance of a consolidated battalion level kitchen which we have designated as the XM-75. One important result concerns the manpower requirements of this kitchen. A comparison of the current system, the XM-75 staffing at Camp Edwards and the staffing required if we go to a meal discipline involving 2 hot meals and 1 MCI daily, are shown on the next slide (Vu-graph No. 10).

We also found that troop acceptability of the food was somewhat batter, when compared to the food supplies in previous years by their company kitchens (Vu-graph No. 11).

Without a doubt, the XM-75 kitchen offers a great potential for manpower savings. However, I want to emphasize that the Army will still have a need for the company kitchen for the foreseeable future. This is due to the fact that unit location and mission on the battlefield precludes across the board consolidation. At tha present time, we are planning a follow-on experiment with the Marine Corps at Camp Pendleton for February 1976. This effort will involve a comparison between the Marine Corps standard battalion kitchen, the XM-75 and a multiple MKT concept. With this experiment, we will complete our work on improvements which can be implemented with the present system in the short term.

The remainder of this project will concentrate on defining a totally new system for the 1980's for both the Army and Marine Corps. A summary of our planned activities during FY 76 and FY 77 are contained on the next Vu-graph (No. 12). We have already begun working on the new system.

In conclusion, we feel that there is a very high success potential for achieving the Army and Marine Corps objectives. In the long term, we will have to eliminate the practice of preparing raw food from start to finish at the point of service. This change will necessitate a much greater dependence on preprepared foods which only require heating for 10-30 minutes prior to serving. We hope to achieve our goal without compromising the acceptability or nutritional adequacy of the food we serve our customers.

MR Erich Pohl — Bonn, 9 September 1975

B R I E F I N G

"War Reserve Food Stocks for the Federal Armed Forces - problems related to foodstuffs and packing technologist"

held at

The 3rd International Symposium "Food for the Armed Forces"

Mr. Chairman, Ladies and Gentlemen:

Let me introduce myself: I am the head of that section in the Federal Ministry of Defense which is responsible for all matters pertaining to food supplies for the Federal Armed Forces; I assumed that responsibility in 1966. Colonel Dr. Sommer, whom you know already, is the pharmacist responsible for our food-physiological guidelines. Oberregierungsrat Dannenberg comes from the Federal Office for Military Technology and Procurement; he and his staff advise my section on all matters related to foodstuffs and packing technologies. He is known to you - he briefed the last symposium in Norway on the subject of "General and Special Operational Rations".

Let me thank you for your invitation giving me the opportunity to speak on "War Reserve Food Stocks for the Federal Armed Forces - problems related to foodstuffs and packing technologies".

My briefing is based on that of Herr Dannenberg dealing in more detail with field kitchen rations and one-man food packets.

I refer to that briefing because, at the present time, the wartime food reserves for the Federal Armed Forces comprise, with the sole exception of the special supply rations for submarine crews, these two groups only, that is to say 80 percent of them are field kitchen rations and 20 percent are one-man food packets.

Currently, planning is concerned with increasing the portion of the one-man food packets to 40 percent, and reducing that of the field kitchen rations to 60 percent. And this for the following reasons:

(1) Planning how to supply the Federal Armed Forces with food in a defense emergency must be based on the modern war image and has to be in keeping with the strategic concepts of the three Services (Army, Navy and Air Force).

These, in turn, based on the concept of forward defense, put great emphasis on operational mobility.

This means that in a defense emergency, it will not always be possible to provide the forces - the field forces in particular - with field kitchen rations: one-man food packets will be needed instead.

(2) In a crisis, food supplies in the Federal Republic of Germany - whose territory will be a theatre of operations - will be rationed at an early stage in order to ensure, as far as possible, food for the population as a whole. As soon as food rationing begins, the food industry must stop the production of special food rations and the appropriate special packing material; production will be reduced to standard commercial food and packing; furthermore, rationalization will permit the production of very few types only.

Under such conditions, the Federal Armed Forces will no longer be able to procure, on the home market, special rations in the form of one-man food packets. Therefore, they will have to rely for a protracted period of time on stocks available.

The budgetary funds required for the increase of the portion of the one-man food packets has not yet been approved. After all, on the basis of the 1975 procurement prices, it would involve a rise in annual expenditure of approximately DM 20 million.

However, this will not be the only change planned in respect to the Federal Armed Forces wartime food reserves. Account has now been taken of the fact that once rationalization begins, commercial food and commercial packing only will be available, and, therefore, the composition of the 80 percent portion of field kitchen rations has been altered significantly:

(1) The old stockage plan provided for a total of 71 different foodstuffs including spices. Of this total, 49 were foodstuffs specially produced for the Armed Forces, 22 were commercial food types.

The new stockage plan for the field kitchen rations comprises merely totals of 39 different foodstuffs including spices; only 15 of these being special foodstuffs for the Armed Forces and 24 commercial.

In other words, the portion of the - by the way cheaper - commercial foodstuffs has increased.

(2) Food stocks are now no longer stored and palletized by rations, which required certain specific sizes of packages. Food is now stockpiled by commodities. This facilitates the supply of food to the forces significantly.

When requesting food from a subsistence depot, all a unit has to do is to put down the ration strength, the number of days and the category of food rations required. You will understand the system, if I tell you that the Federal Armed Forces have established three wartime categories of rations being composed of food-physiological declaration of value only, namely:

Ration Category I	- for combat troops
Category II 1	- for troops in activation and under training
Category II 2	- for all other components of the Federal Armed Forces.

With that request in hand, the subsistence depot personnel act on their own discretion and assemble, from the stores available, rations for the unit who collects them palletized by commodities. The depot personnel will also stick labels on the pallets informing the unit of how the rations can be used to provide the soldier with breakfast, lunch and supper. The user unit may follow this informative advice, however, is not obliged to do so, and may just as well distribute the rations as deemed fit in view of the combat situation.

(3) The Federal Armed Forces strictly separate stockpiling in peacetime and food supply planning in wartime The only purpose of the stockpiling plan is the computation of storing quantities.

Wartime food supply planning takes account of the stocks available and is carried out each time food is collected at the subsistence depot.

In the first few years of their existence, the Federal Armed Forces, just like the US Forces, planned to implement a "wartime ration scheme" binding for all Federal Armed Forces personnel. Several years ago, we realized that adhering to this perfectionized food supply scheme would deprive us of exploiting the possibilities the Federal Republic of Germany as a theatre of operations might, in fact, afford us to supply our troops with food; thus, we dropped this standardized supply scheme.

(4) The Federal Armed Forces wartime supply planners must expect that the Federal Republic of Germany will be a theatre of operations - of a depth of approximately 300 km, and a length of approximately 750 km. That means short shipment lines. The population living in this theatre of operations must be supplied with food - which may involve restrictions, bottlenecks and reduced rations. In other words, in this theatre, the Federal Armed Forces will have available not only their own stocks, they will also be able to have recourse to the food supply organizations of the Federation and the various Federal States. Accordingly, as regards food supply, the Federal Armed Forces will rely on the following policy:

The Federal Armed Forces will procure their food supplies as long as possible on the home market - this applies to all types of foodstuffs, fresh food or tinned food. Should the situation change and should it no longer be possible, locally, to supply the forces with that food, they will have to fall back on one of the approximately 60 subsistence depots in which the war reserves are stored and controlled. These depots are deployed in consonance with the strategic concepts of the three Services; they form a closely meshed network, thus again, shortening the supply shipment lines.

These are the reasons for our changing the portions of one-man packet and field kitchen rations.

The latter portion comprises foodstuffs storable at temperatures of plus 6 to plus 18° Celsius. They must have a long shelf-life and retain their flavor. In order to facilitate distribution, they should, as far as feasible, be portioned as required, for instance, ready for distribution to a platoon, a section - right down to the individual soldier. They should permit easy handling and quick cooking and be ready for consumption; hot-meal rations should merely require warming up.

In order to ensure the desired shelf-life and lasting flavor, processing technologies and their specifications are continuously adapted or updated to satisfy the requirements of the latest state-of-the-art. Only physical - mechanical - preservation processes are permitted.

Shock-heating to high temperature and rotation sterilization helped to improve the sensory qualities of tinned food considerably and, likewise, to prolong shelf-life.

But planning and the selection of nutrition raw material oriented towards a long shelf-life, including the various processing technologies, which time forbids to describe in detail, are not our only concern. We must also concentrate on packing, - primary packing in particular - which plays an important role. In recent years, metal packing material has been replaced more and more by soft and semi-rigid foil. We use mainly an aluminum polypropylene compound which has proved as flavor-, vapor- and oxygen-tight as white-metal tins - it also matches their sterilize abilities, and, moreover, it is surprisingly superior in maintaining the tastiness of preserved food. The reason being that in a white-metal tin, chemical interaction takes place between filling, iron and tin and the dissolved metal substances lead to catalytic acceleration of the decay of the filling. Such chemical interaction between food and packing material is not possible when using foil.

Even now, foil has replaced metal for packing such foods as:

> Ready dishes, bread, jam and marmalade, milk powder, soft cheese, meat and sausage, roasted coffee, potato products, fish and vaporized milk.

To give you an idea of the <u>shelf-life</u> of some field kitchen foodstuffs, they are: < > except « »

6 months for non-perishable sausage, e.g. salami

4 months for cheese, also for bread (although in the latter case there exist certain special regulations, which I will leave aside here)

2 years for commercial foodstuffs, and

4 years for certain specially produced rations.

I will now turn to the one-man food packet. Conventional tins are no longer used for this type of ration. This <u>applies even to</u> sterilized liquid food (e.g. ready dishes, cold cuts).

<u>The Advantages of Soft-Packing are</u>:

No more tin openers; the producer can handle the semi-rigid container in the same way as he handles tins; it has a sterilizing protective effect on the filling; no injury hazard for the consumer; they can easily be warmed up in hot water or over an open flame; ready dishes can be eaten cold.

<u>All in all, the advantages of the new kind of one-man packet rations can be summed up as follows</u>:

Their contents are no more rigidly divided into breakfast, lunch and supper; rations are composed to satisfy physiological requirements in a way permitting the consumer to have - in a period of 24 hours - 2 warm meals and several cold meals - including beverages.

Gentlemen, during our lunchbreak, you had an opportunity to get to know the ingredients of our new one-man packets - though owing to import regulations - we could not display here the entire range of our foodstuffs. Herr Dannenberg will give you our graphs and I hope that the legends will provide you with all that information on our one-man packets you may wish to get.

In the beginning, I said that we have only one kind of special ration in the Federal Armed Forces, namely, the submarine rations. You will now understand that the new one-man packets enable us to provide all kinds of special ration for troops in special employment, for instance for airborne units, long-range reconnaissance units, shelter crews, etc.

This very satisfactory situation does, of course, not diminish the responsibility of Herr Dannenberg and his staff - it will remain his task to cooperate with the competent research institutions of our country in order to improve and develop further the food and packing technologies to our benefit. We observe very closely all research efforts of interest to the Armed Forces in order to be able to translate their results, if appropriate, into concrete measures to improve our stockpiling.

Thus, let me summarize:

The rations of the Federal Armed Forces are composed of the permissible minimum number of foodstuffs - without detriment to variety; this is rational and economical.

Stocks are subject to continuous review and changes to keep abreast of the latest state-of-the-art of logistics, economy, food physiology and technology. Fresh knowledge can be translated immediately since the very strict formal procedures governing development, testing and introduction of new defense equipment in general, need not be applied to changes in food stockpiling.

The stocks, palletized by commodity, offer a great range of variety to the user. The subsistence depot in question decides, at its own discretion, on the composition of the rations requested by units, bearing in mind quantities available and the physiological value of the various foodstuffs.

Thus, it can be said that this kind of stockpiling leaves ample room for improvising supply in a defense emergency. I would say that this kind of stockpiling and rationing are better suited to guaranteeing food supply in wartime than a perfectionized supply system which is too rigid to respond to unforeseen circumstances and is - therefore - vulnerable.

Thank you, Ladies and Gentlemen.

Insuring the Microbiological Safety of Military Feeding Systems

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The basic principles and standards for food service sanitation prescribed to prevent food poisoning and foodborne infections in military feeding systems are presented in various military manuals (e.g., U.S. Army Regulation No. 40-5. 1974. Food Service, Medical Services, Health, and Environment Headquarters, Department of the Army, Washington, D.C.). If such guidelines are not enforced, a combination of abuses may occur and result in a microbial health hazard. Therefore, in most cases where military feeding systems are under study by the Natick Development Center (NDC) the Food Microbiology Group, Food Sciences Laboratory monitors their microbiological safety.

FEEDING SYSTEMS

Various types of feeding systems have been monitored (Table 1). A garrison feeding system may serve anywhere from less than 100 (small) to over a thousand individuals (consolidated). In addition, there may be a specialty meal facility serving special meals (e.g., pizza, fried chicken) or a fast food unit serving short orders (e.g., hamburgers). The food is usually served within a few hours of preparation in garrison. Therefore, even though the food may be abused there is normally inadequate time for contaminating bacteria to multiply to a level which would present a health hazard. In the centralized food preparation facility (CFPF) combinations of thermally processed, chilled, frozen, and fresh items are prepared centrally and distributed to satellite dining halls. Foods are often consumed days or weeks after their initial preparation. Thus, if a food is mishandled there may be adequate time for contaminants to multiply and create widespread food poisoning. At Warren Air Force Base, Cheyenne, Wyoming, precooked, frozen meals are prepared for distribution by refrigerated vans to several states. Meals prepared in the field may be served at a kitchen site or may be placed in insulated containers and transported to sites within 15 miles and served.

ENVIRONMENTAL FACTORS

1. Sanitation. When monitoring the microbiological safety of feeding systems, the major emphasis was placed on constant surveillance of environmental factors such as sanitation and temperature. The evaluation of sanitation was performed by visual inspection and microbial counts using primarily RODAC (replicate organism detection and counting) plates. Swabs were used only for irregularly shaped surfaces. RODAC plates, representing 25.8 cm^2, provide a visible record of the effectiveness of sanitizing procedures and are a valuable tool in educating personnel. The number of plates used for an evaluation of the sanitation of a surface was related to the area under consideration (2,3). A satisfactorily sanitized surface was one where half or more of the total number of plates used contained 50 colony forming units (CFU) or less with no plate exceeding 100 CFU and the average total count was no more than 75 CFU/25.8 cm^2. It is important in monitoring cleanliness and sanitation

that visual inspection be supplemented by microbial counts (Table 2). Experience showed that items may be visually clean but be microbiologically unacceptable and vice versa. Of the 34 surfaces which were microbiologically acceptable by RODAC plates 26 were visually unacceptable. Of more importance, 17 of the 50 surfaces microbiologically unacceptable were visually acceptable.

2. Temperature and time. Proper control of time-temperature profiles during food preparation, storage, and serving is widely stressed as a means of controlling foodborne microbial hazards, but often disregarded. Temperature constraints as recommended in Army Regulation No. 40-5 are outlined in Table 3. The temperatures shown are recommended for eliminating and/or preventing the multiplication of organisms which may cause a health hazard and not necessarily to assure acceptability by the consumer. Although the internal temperature recommended for eliminating Salmonella from poultry is 74°C, poultry is usually cooked to an internal temperature of 82-85°C to assure acceptability by the consumer. To assure the destruction of the parasitic nematode (Trichinella spiralis) in pork, an internal cooking temperature of 66°C is recommended. However, for acceptability it is often cooked to an internal temperature of 77°C.

A few foods (e.g., roast beef) having primarily surface contaminants, may safely be cooked to internal temperatures of 60°C or slightly lower. Regardless of the final temperature, cooked roasts should be maintained at temperatures (> 50°C or < 18°C) which do not allow the germination and multiplication of surviving Clostridium perfringens spores which may be present. At 46°C a population of C. perfringens could double every 12 min. (1)

In the military feeding systems, it is required that hot foods be maintained at 60°C or above and cold foods at 7°C or less.

MICROBIOLOGICAL ANALYSIS

Microbiological tests (Table 4) were used for end-product analysis or to determine the effect of inadequate time-temperature profiles and sanitation on the microbiological quality of the food. The constraints listed in Table 4 are for processed foods and were not difficult to conform to. The aerobic plate count was routinely used as an indicator of adequate processing and sanitation. Counts greater than 100,000/g would suggest conditions may have existed which allowed the survival and multiplication of foodborne pathogens. Test for coliforms and fecal coliforms were also used to indicate adequate processing as well as post processing contamination since these organisms are heat sensitive. The presence of fecal coliforms indicates that enteric pathogens such as Salmonella may be present. On occasion these tests were supplemented with an analysis for a specific food poisoning organism, such as Staphylococcus aureus or Clostridium perfringens. All determinations were performed as previously described (2,3).

The effect of adequate processing on the microflora of meat loaf may be seen in Fig. 1. Raw ground beef had 2.4×10^6 total aerobes and > 1100 coliforms and fecal coliforms. Cooking to an internal temperature of 59 to 75°C reduced the counts of total aerobes, coliforms and fecal coliforms to acceptable levels. Pre-cooked, frozen foods prepared at Warren AFB for distribution to various missile sites were considered to be of good microbiological quality if the total aerobic, coliform and fecal coliform counts were respectively, < 100,000, 100, and negative per gram. Any lot exceeding either of these criteria were rejected. The microbiology of 10 precooked, frozen foods prepared at Warren AFB is shown in Table 5. All 10 products had fewer than 1000 total aerobes/g. Only two samples contained coliforms, but fewer than 10/g. Meat loaf and country steak were the only foods that contained any fecal coliforms and in these two cases < 1/g. None of the samples contained any Staphylococcus aureus. It is evident that the central production facility has the capability to process foods that are well within the recommended microbiological constraints. Experience may show that certain of these constraints (Table 4) should be lower.

As previously shown in Fig. 1 end-product analysis is not a good indication of the microbiological quality of the initial raw materials. Furthermore, it has been our experience that products of acceptable microbiological quality can be produced under marginal sanitary conditions. Low counts in the final product may be the result of excessive terminal thermal processing or for frozen foods of the extended time of storage. In addition, microbial analysis of the end-product is after the fact and does not focus on a specific trouble spot. This further emphasizes the importance of placing major emphasis on constant surveillance of time-temperature profiles and sanitation when monitoring the microbiological safety of feeding systems.

SUMMARY

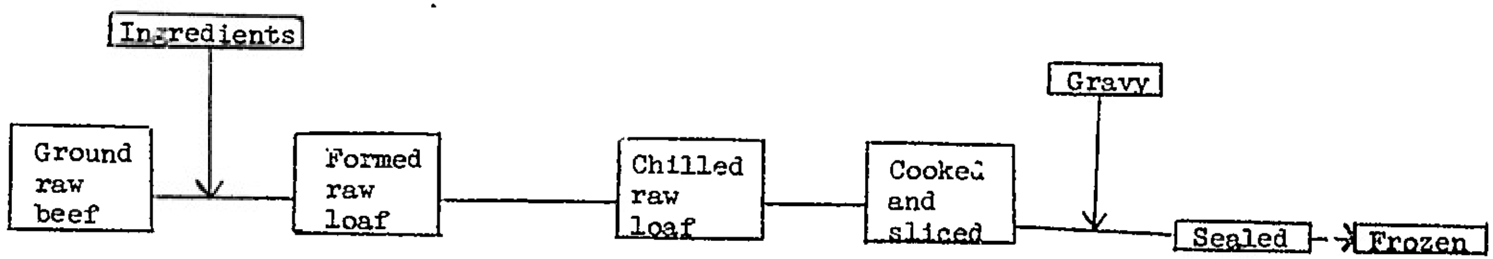
In our attempt to insure the microbiological safety of military feeding systems under study by the NDC we placed major emphasis upon surveillance of the major causes of food poisoning outbreaks: inadequate refrigeration, heat processing, sanitation and hygiene of workers. Such a system enables one to detect and correct departures from good manufacturing practices before they result in a health hazard. Microbiological tests were used to determine the effect of poor handling procedures on the microbiological quality of a food during preparation and serving and to verify the microbiological quality of the end-product.

References

1. Arbuckle, R.E. 1960. The influence of temperature on the growth of Clostridium perfringens. M.S. Thesis, Library, Indiana Univ., Bloomington, Ind., 1960.

2. Silverman, G.J., Powers, E.M., Carpenter, D.F. and Rowley, D.B. 1975. Microbiological evaluation of the food service system at Travis Air Force Base. Technical report 75-110-FSL, U.S. Navy Publications and Forms Center, NPFC Code 1032, 5801 Tabor Ave., Philadelphia, PA 19120.

3. Silverman, G.J., Powers, E.M., and Rowley, D.B. 1975. Microbiological analysis of the food preparation and dining facilities at Fort Myer and Bolling Air Force Base. Technical report 75-53-FSL, U.S. Navy Publications and Forms Center, NPFC Code 1032, 5801 Tabor Ave., Philadelphia, PA 19120.



	Ground raw beef	Formed raw loaf	Chilled raw loaf	Cooked and sliced	Gravy	Sealed	Frozen
Total aerobes	2.4×10^6	1.3×10^6	1.2×10^6			2.4×10^3	9.5×10^2
Coliforms	> 1100	> 1100	> 1100			0	0
Fecal coliforms	> 1100	> 1100	> 1100			0.8	0
Fecal streptococci	2	4	3			< 10	< 10
Staphylococci	0					0	0
°C		12-16	9-16	59-74	86		

Figure 1. The effect of processing on the microflora of meat loaf.

Table 1. Types of military feeding systems monitored

Garrison Systems
Small
Consolidated
Specialty Meal Facility
Fast Food Unit
Centralized Food Preparation Facility
Centralized Production Facility
Field

Table 2. A comparison between visual and RODAC plate evaluation of sanitation

Number of surfaces evaluated	Ratio (%)[a]	
	Vs/Rs	Vu/Ru
144	68/94 (72)	33/50 (66)

[a]Percent of those surfaces RODAC satisfactory (Rs) or unsatisfactory (Ru) which were also visually satisfactory (Vs) or unsatisfactory (Vu), respectively.

Table 3. Recommended safe temperatures for food preparation and storage

Stage	Temperature
Frozen storage of raw foods	-18 C
Tempering	-12 C for 7 days ≤ 4 C for 72 hr Running water ≤ 21 C Part cooking process
Internal Cooking temperature	
Poultry	74 C
Stuffing (dressing)	74 C
Pork	66 C
Refrigeration of prepared foods	≤ 7 C for ≤ 36 hr ≤ 4 C for ≤ 5 days -18 C for ≤ 45 days
Reheating of refrigerated precooked foods	> 60 C
Serving	≥ 60 C or ≤ 7 C

[a]U.S. Army Regulation No. 40-5. 1974. Food Service, Medical Services Health and Environment Headquarters, Department of the Army, Washington, D.C.

Table 4. Microbiological tests for monitoring processed foods

Food Analysis	Constraints Count/g
Aerobic plate count	$\leq 1 \times 10^5$
Coliforms	$\leq 1 \times 10^2$
Fecal coliforms	Negative
Staphylococcus aureus	$\leq 1 \times 10^3$
Clostridium perfringens	$\leq 1 \times 10^3$

Table 5. Microbiological analysis of processed foods

Foods	Total aerobes (10^2 CFU/g)[a]	Coliforms (MPN/g)[b]	Fecal coliforms[c] (MPN/g)[b]
Pork chop suey	2.8	0	0
Roast pork	< 1.0	0	C
Roast turkey	< 1.0	0	0
Beef pot pie	< 1.0	0	0
Meat loaf	9.5	0	0.8
Country steak	< 1.0	0.5	0.1
Chicken, fried	<10.0	0	0
Macaroni and cheese	1.3	0	0
Potato, O'brien	< 1.0	1.4	0
Green beans	< 1.0	0	0

[a] 100 colony forming units per gram

[b] Most Probable Number per gram

[c] Organisms which have the ability to produce gas in EC broth at 45.5°C after preliminary selection in Bacto-lauryl tryptose broth

LATEST DEVELOPMENTS IN FOOD COMPRESSION

D. E. Westcott

Weight and bulk are extremely important factors to be considered in the design of foods for military operations involving storage, transport, and delivery. Reduction of up to 90 percent of the weight of foods delivered to or carried by the combat soldier is achievable by means of dehydration. The quality of many "sensitive" foods has been maintained at a high level through the application of freeze-drying, although this process, by its very nature, does not result in any significant reduction in bulk.

In 1969, Brockmann presented an analysis of commercially packed foods which revealed a wide variation among common foods with respect to their weight and bulk effectiveness for providing nutritional energy (Table 1). The data are based on values for net weight, gross weight, and cube of commercially packed foods used by the military. The caloric value of the edible portion corrected for refuse and cooking losses was taken from the Defense Supply Agency Handbook 1338.1. Using a requirement of 3,600 kcal per man per day, and by simple calculation, the man-day equivalent of one kilogram and of one cubic meter of packaged food was derived.

Immediately apparent from Table 1 is the observation that packed foods generally have a density substantially less than water (1000kg/cu meter). The low density is mainly due to voids within the packed product, which in the case of chicken amounts to around half the volume of the crate. Weight effectiveness of packed food as shown by man-days per kg is primarily controlled by the concentrations of water and fat and secondarily by the weight of packaging and packing materials, inedible waste and cooking losses, and non-digestible components. Bulk effectiveness as identified by man-days per cubic meter is controlled by the bulk density (gross weight per cu meter) plus all the factors which influence the weight effectiveness of packed food.

The logistic implications of feeding soldiers, either en masse or individually, at the end of complex, often unrefrigerated, supply systems bring the issues of food weight and bulk into sharp focus. Table 2 provides a picture of various military feeding systems from the perspective of caloric effectiveness based on weight and on bulk.

The Standard B-Ration is designed for mass feeding under field conditions which preclude the use of refrigeration. It requires field cooking and baking facilities and trained food service personnel. Non-perishable foods are generally provided as canned items. The Submarine Endurance feeding system resembles the B-Ration with the important exception that limited facilities for frozen storage are available.

Meal, Combat, Individual, contains two canned items, plus either cookies, crackers or candy, and an accessory pack. The canned items and the non-edible components of the accessory pack contribute to poor weight and bulk efficiencies. Although the major component of the Long Range Patrol Food Packet is dehydrated, an accessory pack containing non-edible components and the relatively high percentage of packaging materials combine to subtract from its weight effectiveness. Since freeze-drying results in only a minor decrease in volume, the bulk efficiency of this packet is inferior to the Standard B-Ration. The Precooked Frozen meal is used by the Air Force to provide a hot meal for long flights. Data presented in Table 2 cover the 4 dinner menus which require supplementation with a beverage, salad, bread, and dessert. Menu items are relatively high in water, and trays, packaging and packing account for 25 percent of the gross weight and add excessively to the bulk. As a result these meals are clearly inferior in both weight and bulk effectiveness. The 25 Man Uncooked Meal was formerly the projected successor to the current Standard B-Ration and was intended for use under the same conditions. Its major advantages were that it was unitized to contain all food components for 25 men, except the bread, and that it had a markedly superior weight effectiveness since it made maximum use of dehydrated components. Again, since freeze drying provides no significant reduction in volume, its bulk effectiveness was of the same magnitude as the Standard B-Ration.

The concept of the Food Packet, Individual, Combat is currently under development. The parameters listed in Table 2 represent, independent of packing, a density of 1.08, 3.5 kcal/gram, and 918 cc per man-day (approximately equal to 7 king size packages of cigarettes). To achieve such requirements priority is given to measures, such as compression, to attain a much greater density for freeze dried foods. Alternative measures based on fabricated products having a high caloric content or a restriction to a few common high calorie foods were deemed to carry a low potential for success in view of the uniformly poor acceptability of unfamiliar foods and the recognized need for variety.

During the last ten years, one of the major thrusts of the R&D program here at Natick Development Center has been the effort directed toward reduction of weight and volume. Since it is generally accepted that dehydration is an effective means of reducing weight, our attention has concentrated on compression as a means of achieving corollary reductions in food volume. Three approaches have been actively pursued:

1. Reversible compression of foods for consumption in a reconstituted state.

2. Non-reversible compression of foods for consumption from the compressed state.

3. Dual purpose compression of foods for consumption in the compressed form or after reconstitution to the conventional or familiar form.

The feasibility of reversible compression, compressing foods and subsequently restoring them to their original form, was uniquely demonstrated by Tronchemics Corp. under a Quartermaster contract in the early 1960's. Their technique of plasticizing freeze-dried cellular foods with small amounts of water to 5-13% moisture, mechanically compressing, and redrying to less than 3% moisture has been developed and applied to a wide range of products. The first product to be commercially produced for the military using this process was freeze-dried compressed green peas, illustrated in Figs. 1 and 2. The compression ratio for peas, as is true with other products, is proportional to the solids content or moisture content of the fresh product and therefore, the dehydration ratio--4 to 1. Figure 3 shows freeze-dried green beans and the compressed product with a 16 fold reduction of volume. Table 3 lists those foods which have been or are currently under active development. Wherever air drying results in acceptable quality, it is used in order to take advantage of the economy over freeze drying as in the case of onions and apples. Nearly all products are designed to reconstitute in hot water in a matter of a very few minutes to virtually their original precompressed shape and organoleptic quality characteristics. One can see that it would be possible to design a menu, although obviously limited, which would achieve a very high bulk effectiveness.

In addition to the obvious logistical advantages, these products result in significant savings of packaging materials. This is important from both a cost standpoint and also ecologically, i.e., reduction in waste to be disposed.

The US Military Services have been slow to take advantage of these new foods, although the Navy has shown the greatest interest due to limited storage space on shipboard and especially in submarines. We are experiencing the traditional problem that occurs with most new technologies. Initial costs are high until the demand is great enough to stimulate development of economical mass production techniques. Especially in the current economic climate, high demand cannot be generated because of the relatively higher costs of compressed foods compared to the conventional forms--frozen and canned. We must find a means of breaking this "vicious circle."

Developing the concept of reversible compression one step further is demonstrated by a modularized pack of compressed dehydrated food bars and cubes of concentrated sauces and seasonings. Figure 4 shows a cut-away of a recent module which was prepared by the Pillsbury Company with funds provided by NASA. Figure 5 shows the same module unpacked. By mixing and rehydrating bars and cubes in prescribed combinations this pack will provide 32 familiar foods in servings averaging 700 kcal. For example, to prepare beef stew, a diced beef bar, a mixed vegetable bar, and two dark gravy cubes are mixed and hydrated. For chicken and rice, a chicken bar, a rice bar, and a chicken gravy cube are mixed and hydrated. This concept, as shown, results in a bulk effectiveness of 964 man days per cubic meter which approaches the target set for the Food Packet, Individual, Combat concept.

A limited number of conventional foods, by their very nature, are calorically dense and can be eaten as is or "out-of-hand." The prime example of this type of food is candy. A chocolate bar, for instance, provides about 5 kcal/g and has a density of 1 g/cc or a bulk effectiveness of 1388 man days per cubic meter. The six candy bars used in the new Meal, Ready-to-Eat ration have an average bulk effectiveness of 1170 man days per cubic meter. Confections are also versatile in that they can be made into configurations that are most efficient in regard to packaging, as well as for consumption.

Some effort has been expended toward the development of other non-reversibly compressed food bars. For example, formulated compressed cereal bars have been used for many years as components of operational and survival food packets. Recently, improvement in their acceptability was made by incorporating encapsulated orange and lemon flavors. Certain dried fruits, such as dates, figs, maraschino cherries, golden raisins, and sesame and nuts, have been demonstrated as suitable for compression into acceptable stable food bars. Other fruits, such as apricots, prunes, and brown raisins, discolor excessively during storage. It is necessary to dry the fruits to a higher degree than the commercial item, i.e., to 7-14% moisture, in order to prevent extrusion and gumminess during compression and to provide adequate stability. However, when this is done, the resultant bar is much too hard to eat. To alleviate this problem, it was found that the addition of 2% lecithin was dramatically effective in improving the textural characteristics of compressed fruit bars. Shear force and toughness were reduced by 20-30%, and panel ratings for texture improved by 30%. The bulk effectiveness of this type of food bar is very high, ranging from 1400 to 1600 man days per cubic meter depending on the specific formulation. This is unquestionably due to the high sugar content and the high density of sugar itself.

In the area of meat products, a prototype beef Jerky bar (smoked, dried, compressed beef) has been developed which has received high acceptance ratings and shown good storage stability. However, most dehydrated fruits, vegetables, and meat products, whether freeze-dried or not, cannot be compressed into dense bars which can be readily eaten as is. They are generally too hard and dry unless they are formulated with other food ingredients to modify their textural and organoleptic properties.

This leads us to the third area of effort which is called dual purpose compression of foods intended for consumption in the compressed form or after reconstitution to the conventional or familiar form. Such food bars would be suitable for direct consumption, or as circumstances permit, the same bar can be hydrated in either cold or hot water to yield a familiar food. Figure 6 shows several such bars before and after hydration. The concept of dual purpose bars is not only basically consistent with the concept of Food Packet, Individual, Combat, but represents an additional dimension for their potential utility. This advanced concept has been further exploited through a contract with Swift & Company and has provided a total of 20 dual purpose bars. As shown in Figure 7, all major classes of menu items are represented. The concept of dual purpose food bars as shown in Figures 8, 9, and 10 was recently evaluated by Special Forces troops on a training exercise in a temperate climate. The concept was shown to be technically feasible, but also demonstrated that much more research is needed to establish all the technical and psychological parameters for completing development of suitable food and packaging designs. For one thing, the flavor of a food bar in respect to salt, spicing, and other flavor levels may be too intense when eaten in the dry state if it is formulated correctly for reconstitution with water. Conversely, if it is flavored suitable for eating dry, then it may be too bland when reconstituted. Some attempts have been made to encapsulate portions of the flavor so that they will not dissolve rapidly in the mouth but will be released when the bar is rehydrated. This requires much more exploration.

Food bars composed of several different dry foods present a peculiar problem. For example, a beef stew composition would likely contain meat, potatoes, vegetables, and gravy each having its own compression and rehydration characteristics. The optimum conditions for one component may be widely different from the others. Thus, compromises in formulation, processing, and performance would undoubtedly be necessary.

The most difficult problem with dual purpose food bsrs is the precise control of texture. It is essential that the bars be compact and firm enough to hold together from time of production to consumption. However, they must not be too hard to bite and masticate. They must also be easily rehydrated. Our objective is to achieve rapid reconstitution in hot water (if appropriste for the item) and within 10 minutes with cool or ambient temoerature water. Methods of formulating to attenuate. the hsrsh dryness that is frequently encountered must be explored further.

The bulk effectiveness of these prototype food bars (without packaging) is on the order of 1000 man days per cubic meter which, again, is in the target area. Now the potential exists for combining various types of compressed and dual purpose food bars into food or ration packs which will meet our objectives of high acceptability, storage stability, and complete nutrition in a truly minimum weight and volume.

In summary, the preceding comments have directed attention to the weight and bulk effectiveness of various foods as an energy source for human nutrition. It was noted that common foods as commercially packed have a relatively low bulk density and are highly variable with respect to both weight and bulk effectiveness in supplying nutritional energy. Weight and bulk effectiveness become increasingly significant in supplying food to soldiers at the end of long, complex supply lines. Reversible compression provides a realistic mechanism for reducing bulk by more than one-half. For soldiers operating under conditions which require them to carry their food supply, effort to date on dual purpose compressed food bars supports the feasibility of providing a variety of familiar meal items at three times the bulk effectiveness of our current operational rations.

TABLE 1

WEIGHT AND BULK EFFECTIVENESS OF COMMON FOODS AS PACKED

PACKED FOOD	NET WT	GROSS WT KG/CU METER	MAN DAYS* PER /KG	MAN DAYS* PER CU METER
CHEESE, AM. 5 LB LOAF	13.6	871	.97	836
FLOUR, WHEAT, SACK	45.5	717	.99	716
HAM, 10-14 LB CANS, CASE	36.4	1007	.48	490
BEEF, GROUND 50 LB CARTON	22.7	739	.55	406
SALMON, #1 CAN, CASE	21.8	637	.39	250
CHICKEN, FRYER, CRATE	24.5	518	.26	138
PEAS, 303 CANS, CASE	10.9	659	.13	85
CORNFLAKES, 50 SERVINGS	1.4	82	.79	63
ORANGES, CRATE	15.9	534	.11	56
LETTUCE, ICEBERG, CRATES	10.9	209	.02	5

*1 MAN DAY = 3,600 KCAL

TABLE 2

WEIGHT AND BULK EFFECTIVENESS OF PACKED MILITARY RATIONS

PACKED RATION	GROSS WT KG/CU METER	MAN DAYS* PER /KG	MAN DAYS* PER CU METER
STANDARD B-RATION	578	.55	318
SUBMARINE 120 DAY ENDURANCE	603	.62	367
MEAL COMBAT INDIVIDUAL (12 UNITS)	501	.35	173
FOOD PACKET L R P (24 UNITS)	308	.70	215
PRECOOKED FROZEN MEAL (12 UNITS)	276	.31	85
25-MAN UNCOOKED MEAL (1 UNIT)	369	.88	328
FOOD PACKET INDIVIDUAL COMBAT**	1084	.97	1059

*1 MAN DAY = 3,600 KCAL ** TARGET (PACKAGED ONLY)

TABLE 3

REVERSIBLY COMPRESSED FOODS

VEGETABLES	COMPRESSION RATIO	PRECOOKED MEATS	COMPRESSION RATIO
PEAS	4	BEEF	3.5
GREEN BEANS	16	CHICKEN	3.5
SPINACH	11	PORK	3.5
ONIONS	5	SHRIMP	4
CORN	4	MEATBALLS	3.5
CARROTS	8	SAUSAGE LINKS	3.5
CABBAGE	16		
SAUERKRAUT	20	MISCELLANEOUS	
LIMA BEANS	2	COTTAGE CHEESE	4
		FLOUR	1.2
FRUITS		CAKE MIXES	2
CHERRIES	8		
BLUEBERRIES	8		
APPLE SLICES	2		