MILITARY FOOD ENGINEERING *and* RATION TECHNOLOGY

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Forward: Feeding the Warfighter

MILITARY necessity has always been a key driver of technological innovation. From multimillion dollar aircraft to computer networks and personal equipment, much of the technology that has shaped our world originated in military research. However, the most advanced equipment and the most staggering military capabilities need skilled and dedicated individual Warfighters to turn technological potential into battlefield effectiveness. The individual Soldier, Sailor, Airman, and Marine is THE most flexible and adaptable weapon system of the United States Military.

The Department of Defense Combat Feeding Directorate (DoD CFD) is responsible for making that weapon system perform as effectively as possible. The scientists and engineers of DoD CFD conduct state-of-the-art research in a broad array of fields to ensure that Warfighters have the fuel they need to optimize both physical and cognitive performance.

Military ration development must deal with constraints far beyond those encountered in the civilian food science industry. Operational rations must meet stringent shelf-life requirements in order to be useful to an expeditionary force. The Meal, Ready to Eat™, for example, has a minimum shelf life of three years at 80°F (27°C). They must impose a minimal burden on the military logistics system at all levels. Weight and volume are at an absolute premium for rations that may be in a military transport plane one day, airdropped the next and on a Warfighter's back soon after. Variety and acceptability are also key considerations. Warfighters in austere environments rely on the operational rations developed by DoD CFD for weeks or months at a time, and rations that are not universally appetizing to the man or woman in uniform will go unconsumed, with negative impacts on physical and cognitive performance. When your customer base is heavily armed, it's a good idea to keep them happy!

Producibility is also a key constraint in the ration development process. Military rations are procured by the millions, and must be produced efficiently and economically. One of DoD CFD's key tasks is to bridge the gap from laboratory to factory to foxhole, ensuring that rations provide the functional and operational capability required by Warfighters worldwide. Nutrition, another important factor, allows DoD CFD to ensure that Warfighters can perform at their peak capacity over long periods of time.

In order to overcome these constraints and provide new capabilities, DoD CFD pursues six major lines of inquiry, known as thrust areas. Research into Revolutionary Packaging Technologies permits ration quality to be maintained over long periods of time and to reduce both packaging and food waste. Novel Preservation & Stabilization Technologies use cutting-edge food processing technology to prevent spoilage while maintaining taste, texture, and other sensory qualities. Performance Optimization research seeks to identify and validate, through sound science, dietary supplements and phytonutrients,as well as incorporation in appropriate ration components to optimize both cognitive and physical peformances of the Warfighter. New Modeling and Simulation techniques allow food scientists to accurately predict shelf life and to ensure that rations are as appetizing when they come out of the package as they were when they were produced. Food Safety and Biosensors research gives food inspectors the tools to provide real time, actionable intelligence on potential, naturally occurring and intentional contaminants in the ration supply chain. Finally, the Equipment and Energy Technology thrust area focuses on reducing the energy requirements of food preparation, allowing expeditionary forces to accomplish their missions with a smaller logistical burden and environmental impact.

DoD CFD stands at the forefront of all food science, not just military ration development. Building on a history of military innovation from the tin can of the 19th century to irradiation research and the development of flexible packaging, DoD CFD is a leading developer of advanced food processing techniques, such as microwave assisted thermal stabilization and high-pressure assisted thermal stabilization.

At all times, the research and development that takes place at DoD CFD is driven by the needs of the Warfighter in operational environments that change constantly. Since the beginning of Operating Enduring Freedom in 2001, DoD CFD has produced two entirely new ration concepts: the First Strike Ration®, which provides a full day's nutrition in a single lightweight pouch allowing an eat-on-the-move capability, and the Unitized Group Ration-Express™, a self-contained, self-heating group ration for 18 Warfighters that requires no fuel, no cooks and no equipment. Both of these innovations were specifically designed to meet the demanding requirements of the military in asymmetric combat operations. Moreover, all ration components undergo extensive field testing before being introduced to the Warfighter. This direct feedback allows DoD CFD to proudly claim that all rations are Warfighter Recommended, Warfighter Tested, Warfighter Approved™.

Our mission of providing the best possible rations to the Warfighter will continue into the future. Some of the major challenges we face going forward include continued reduction in weight, volume and equipment energy consumption, improvements in phytonutrient validation and delivery, shelf life optimization, and the ongoing need to meet the changing needs of the military as its mission continues to adapt to changing conflicts. In this volume, you'll learn what we do at the Department of Defense Combat Feeding Directorate and associated laboratories located at Natick Soldier Center to maintain and optimize Warfighter performance. You'll learn how we accomplish this mission, and thus have a snap-shot of our high-risk, high-payoff science and technology investment. The end result is a family of operational rations and field food service equipment that allows our Warfighters to outlast any adversary, anytime, anywhere.

GERALD A. DARSCH

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Section I
Introduction to Military Feeding

An Overview of U.S. Military Field Feeding and Combat Rations

JOSEPH A. ZANCHI

> Understand that the foundation of any army is the belly. It is necessary to procure nourishment for the soldier wherever you assemble him and wherever you conduct him. This is the primary duty of a general.—*Frederick the Great*

BACKGROUND/HISTORICAL

Background and Historical Perspective

THE supply and sustainment of proper food and nourishment for soldiers is an essential component of the success of any military operation, as it has an enormous impact beyond simply nutrition and the physiological requirements (Dolloff-Crane, 2004).The effects and consequences of food extend to morale, discipline, esprit de corps, physical condition and the well-being of an Army. The lack of dependable, quality food supplies can have a debilitating and devastating effect not simply on the performance of individual soldiers but on entire operations, campaigns and conflicts, altering the outcome of battle.

A look at the earliest rations of the United States Army at the dawn of the American Revolution reveals that these were intended to be all-inclusive in terms of purpose, and they remained that way for over a century. During this time, the soldier's nutritional health and diet were considered of little importance and not given much attention. These garrison rations, as they were known, consisted of simple, basic staples of meat and bread and, on occasion, vegetables. These rations provided an allowance of food for one person for one day and were intended to

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serve the unit, the small group, and the individual, as no distinction in operational application existed. The ration was intended to serve small groups and the individual soldier in organized messes, isolated groups, and in all situations to include combat and survival (Koehler, 1958). Preparation of the food was generally up to the discretion of the soldier, and was either performed individually or with his buddies. The first U.S. Army ration was established by Congressional resolution on November 4, 1775:

> Resolved, that a ration consists of the following kind and quantity of provisions: 1 lb. beef or 3/4 lb. pork, or 1 lb. salt fish per day; 1 lb. bread or flour, per day; 3 pints of peas or beans; 1 pint of milk per man per day, or at the rate of 1/72 of a dollar; 1 half pint of rice or one pint of Indian meal, per man per day; 1 quart of spruce beer or cider per man per day, or 9 gallons of molasses per company of 100 men per week; 3 lbs. candles to 100 men per week, for guards; 24 lbs. soft or 8 lbs. hard soap, for 100 men per week (U.S. Armed Forces Food and Container Institute, 1963).

The evolution of feeding soldiers in the U.S. military over the next hundred-plus years, up until the late 1800s, was influenced by the many obstacles and hardships that were faced with each campaign or war, the dictates of circumstances unique to those conflicts, and the advancement of significant technologies relevant to the military. The problems encountered in providing for a wholesome, healthful, sufficient, and acceptable food supply for deployed soldiers as well as growing recognition of dietary deficiencies and their negative impact on soldiers led to further changes to resolve these various issues. Increased awareness and study of nutrition, the link between nutrition and disease, and the need to protect against illness, such as diarrhea and dysentery related to unsanitary conditions, and casualties brought on by tainted or spoiled foods resulted in institutional changes in military feeding (Darsch and Moody, 2009).

The advent of canning as a food processing and preservation method in 1810 and its commercial acceptance signaled a revolutionary departure from previous preservation techniques of smoking, salting, curing, pickling and drying traditionally used by the military. This new food processing method opened the door for extending the shelf life of perishable fruit, vegetables, meat and dairy products, enhanced the quality, variety and acceptability of a soldier's diet, and provided the possibility of more readily supporting the field feeding and sustainment requirements of increasingly expeditionary armed forces. The increased popularity, demand and availability of canned items, as well as development of new land and sea transportation infrastructure and expansion of industrial markets and populations in the late 1800s, helped change the quality and capability of military field feeding for the better and opened the door for still further changes to come.

Military Sponsored Research and Development

The start of the 20th century heralded increased emphasis and focus on nutrition by the military. It also led to the introduction of rations that were intended for specific missions or applications. This was the precursor to the evolution of special purpose rations. Attention was also given to the proper training of Service members in the art of proper cooking and baking, as the Army opened its first training school at Fort Riley, Kansas in 1902. The origin of a more formal ration development effort was started with the establishment of the Quartermaster Subsistence School in 1920 to improve existing rations. The beginnings of modern ration research and development can be traced to this time-frame as the Army opened its new Subsistence Research Laboratory at the Quartermaster Food and Container Institute in Chicago in the late 1930s.

Extensive research was conducted in the decades before and after World War II, which initiated the legacy of collaboration between government, industry and academia in developing improved combat rations. This period of unprecedented buildup of troops, equipment, and production and distribution of war materials to sustain combat operations in both the European and Pacific theaters provided the supreme test for American industrial and military willpower. This period introduced a number of significant changes in rations based on advancements in food technology, as an array of rations including more than 23 different ration meals and supplements were developed, including the C, D and K rations. The C ration was a canned operational ration or true combat ration. The D ration was a survival ration comprised of compact bars that could be eaten on the move, while the K ration was a lightweight parachute ration that was reportedly used interchangeably with the C ration (Longino, 1946). The output of this research was necessary to support the U.S. military might that was now deployed around the world in all climates, conditions and missions. 'Food preparation during World War II focused on the typical company kitchen consisting of three gas-fired stoves, an ice chest, several 32-gallon cans and immersion heaters for washing utensils and pans, and a tent for cooking. Unit initiatives resulted in modifying the 2 1/2-ton cargo trucks into mobile kitchens in an attempt to push the subsistence forward. The Army declared this practice unsafe, however, and returned to the traditional tent cooking method' (Morris, 1992). It is estimated that over 8 million personnel were fed with one billion individual rations during World War II.

Major advancements post-WWII can be linked to each major conflict, war, or campaign, and each new conflict drives a continuous learning process and presents new challenges. Although relatively few changes in rations were made during the Korean era, since soldiers consumed surplus WWII C rations, several new items were introduced at this time, including canned fruits, cakes and bread. Significant changes were made in the Vietnam era with the introduction of the Meal, Combat, Individual (MCI) (Figure 1.1), as military feeding doctrine shifted from a ration basis to nutritionally balanced meals to match battlefield mobility. Additional technical advancements were made in application of freeze dehydration for lighter weight rations and modular configured group rations (Darsch and Evangelos, 2007).

The period of post-Vietnam research and development led to the present day activities conducted under the auspices of the Department of Defense (DoD) Combat Feeding Research and Engineering Program at the U.S. Army Natick Soldier Research, Development and Engineering Center. Basic and applied research and advanced product develop-

FIGURE 1.1. The Meal Combat Individual, introduced in 1958, was used extensively during the Vietnam conflict [U.S. Army photo].

ment now take advantage of emerging, cutting-edge food technologies, and enable the transition of technical and operational improvements to ration platforms and military food service systems. This comprehensive, structured program incorporates the needs of each of the military Services through a balanced and prioritized science and technology investment portfolio. This systemic approach has fostered innovation and leveraged increased scientific understanding to produce significant advancements in materials, packaging, food processing, food preservation, nutrition science and human behavior. The result is a continuous stream of improved rations, food service equipment and systems that align with military doctrine and provide unmatched sustainment support for the joint warfighter like no other time in history.

FIELD/OPERATIONAL CONSTRAINTS

Understanding the Playing Field—*The Continuum of Operations*

Military field feeding operations must be compatible with the full spectrum of potential military actions and options associated with modern warfare. This presents a significant and dynamic challenge for materiel developers, mission planners, logisticians and combat support personnel who serve this critical need. Combat ration systems and food service systems and equipment must be designed to be agile and adaptable to provide the capability necessary to sustain warfighters anywhere in the world, often under extreme and austere conditions. This continuum of operations, supporting the projection and application of land combat power, encompasses a broad spectrum of conflict, operational themes, and specific operational environments. Examination of these operations, and the doctrine that guides military forces in support of national objectives, provide some understanding of the many operational challenges. It also offers insight regarding the relationship between evolving and future military visions of the battlefield and their impact on military feeding concepts and technology application. Lighter weight rations and equipment that support high mobility, rapid response and quick strike operations are essential to effectively support future operations. Increased operational capabilities will be achieved through cutting edge food and nutrition technologies to increase alertness, improve cognitive ability, and reduce stress. Ration systems targeted at mission-specific requirements and improved performance, as well as food service systems that provide robust capabilities that are resource efficient and easily deployed, will be developed to support sustained operations on the future battlefield.

Achieving Strategic, Operational and Tactical Objectives

The challenges in supporting the range of military operations are focused on meeting broad objectives associated with the various levels of war at the strategic, the operational, and the tactical level. From a sustainment perspective, the strategic level coordinates and energizes national industrial base capabilities and resources; the operational level implements plans in a specific theater to support force deployment, distribution, and sustainment; and the tactical level supplies and replenishes forces with combat loads of fuel, ammunition, rations, medical, water and a variety of common supplies (Field Manual (FM) 3-0, 2008).

The significance of these objectives can be found in their interdependent relationship with one another to enable efficient planning and execution with respect to operations, resources and actions. These collective objectives form both the foundation for military action and also the basis for establishing operational requirements to include rations and food service systems that support feeding on the battlefield.

Efforts to ensure the military Services' wartime subsistence requirements are met by maintaining a strong national and global industrial base that are in direct support of top-level national strategic objectives. The total subsistence business area managed by the Defense Logistics Agency (DLA) is a $4+ billion dollar annual program that supports all Services (Miller, 2009). The DLA industrial management program promotes industrial responsiveness to meet surge and sustainment requirements in support of wartime, or other contingency military requirements. Identification of wartime readiness requirements, supplier capabilities, analysis of business practices, and implementation of preparedness measures directly support national level sustainment base capabilities, which in turn support the Services during major contingencies. Extended-duration shelf life requirements for individual operational rations and prepositioning of ration stocks are examples of strategic and operational requirements that present unique challenges for materiel developers. The evolution and successful implementation of Subsistence Prime Vendor (SPV), managed by the DLA Troop Support in Philadelphia, Pennsylvania, is an example of efficient sustainment support at the strategic and operational level. Under this program, the contractor assumes responsibility for inventory, inventory management, transportation and services of theater-level sustainment support for rear area bases, installation dining facilities and distribution of Class I commodities (Class I supplies include all food or subsistence items). SPV contracts continue to be used successfully by all branches of military Service to provide subsistence and Class I support to garrisons, dining facilities (DFACs) and operations in numerous locations around the world. SPV contractors are used extensively throughout Iraq and Afghanistan, supporting warehouses, storage facilities, Class I yards, dining facilities, forward operating bases, and numerous distribution channels, providing direct shipments to and within the theater using reduced lead times, multiple new items and electronic commerce. This initiative creates a unique and efficient commercial-based supply chain management and distribution capability within specific geographic areas, reducing DoD warehousing and redistribution costs. It provides for strategic global vendor coverage and operational sustainment and distribution support within a theater area of operations.

Another successful strategic partnership or mechanism in supporting execution and continuity of U.S. operations across a broad spectrum of functions is the Contingency Contracting or Logistics Civil Augmentation Program (LOGCAP). LOGCAP frees up significant personnel and resources through contracted support functions so that soldiers can focus on military missions as opposed to combat support roles (Dervarics, 2005). LOGCAP is used extensively and effectively to provide what was formerly the task of the military force structure. It is used to carry out day to day operations, such as running rear area cafeteria and garrison DFACs, operating mobile field kitchens at base camps, establishing and cleaning base camps, operating laundry and clothing repair facilities, handling waste disposal, performing maintenance and supply functions, transporting fuel and potable water, and coordinating transportation of vital materiel and supplies from ports or airfields to the front lines.

Logistics contractors supporting current operations have gradually increased over time, due to the complexity and extended duration of global U.S. military deployments (McNulty, 2009). The Army food program in 2009 was responsible for operating over 400 active duty dining facilities worldwide with 19 DFACs, 97 forward operating bases (FOBs) or coalition outposts, and 2 Class I yards in Afghanistan alone, and another 71 DFACs and 52 FOBs in Iraq (Barnes, 2010). The task is large, complex and burdensome, as there are 250,000 soldiers in 80 countries around the globe, with 140,000 soldiers in theater today (Geren, 2009). These commercial partnerships have been successfully leveraged by the DoD and have been demonstrated as a vital and essential component to project and sustain U.S. forces and support global security objectives.

In forward deployments, at the so-called 'tip of the spear', are highly mobile kitchen platforms; modular, lightweight, rations systems; self-heating, unitized group meals; scenario-specific ration enhancements; nutrient-dense individual rations; and performance-oriented, eat-out-of hand ration components. These capabilities support the warfighter, help dictate combat load, impact resupply, and directly influence individual performance and mission success.

Operational Needs Dictate System Performance Requirements

The demands placed on the materiel developer to design and develop rations systems for warfighters are often technically challenging, sometimes contradictory in nature, and always relevant to the Services' often unique operational needs. The objective of product development is to provide producible and affordable products, satisfy identified multi-functional performance capabilities, and deliver solutions that provide essential nutrition and operational flexibility in addressing tactical, mission, and logistics considerations.

Operational needs may include universal attributes or essential characteristics, such as broad consumer acceptability that addresses a target audience's tastes and preferences, as well as regional or ethnic diversity. In order to achieve this, there must be sufficient variety in menu cycles, formulations, and menu balance between beef, poultry, pork, pasta, vegetarian, and seafood selections in order to overcome menu boredom or fatigue.

Another element in universal acceptance is the level of consumer product expectation to include, to the extent practicable, familiar items and commercial branded products. Ration systems must also offer product wholesomeness, balanced nutrition, targeted macronutrient distribution, end item quality and microbiological safety, ease of use, modularity, and self heating. A particularly distinguishing requirement of combat rations is extended shelf life, which is a minimum 3 years at 80°F (27°C) in the case of the Meal, Ready-to-Eat, Individual™ (MRE™), or five years for survival rations. This long shelf life, which far surpasses typical consumer products found on supermarket shelves, is needed to address requirements for prepositioned war reserves of rations. This enables sufficient stockage levels to sustain increased demand during periods prior to production ramp up, and to enable rations to be maintained for long periods of time in abusive, high heat environments, which considerably reduces the shelf life of food products (Darsch and Brandler, 1995).

Combat rations must be transportable and consumable in any environment in the world. Consequently, primary and secondary packaging must support various innovative food processing technologies, yet be extremely durable and reliable. It must protect against rodent and insect infestation, environmental extremes, threat of chemical and biological contamination, and the extreme rigor and stress of the military supply chain which must sustain a globally dispersed, force projection, and expeditionary military force. World-wide climatic extremes to which military materiel and packaging are exposed include variable conditions ranging from arctic cold, intense heat, high humidity, salt spray, penetration and abrasion from blowing sand, dust, and snow, severe wind loading, and combination effects of natural environments such as ozone effects, temperature, humidity, and atmospheric pressure. These factors affect both external and internal packaging conditions. These stringent demands are further exacerbated by rough handling associated with all transportation modes to include air delivery by canopy, and, in some instances, free fall drop to support resupply of units, teams or organizations in remote locations that are far removed from normal supply bases and in areas not easily reachable by ground. Combat rations must support and sustain dynamic operations in diverse operational environments and austere distribution channels that require adaptability, transportation flexibility, and demand uncertainty.

Other ration system characteristics may be extremely focused and intended for unique or special purpose mission applications that may be driven by factors to include increased individual mobility and reduced soldier load, minimal weight and cube constraints, and exposure and physiology of hot or cold climatic extremes ranging from –60°F to 120°F (–51°C to 49°C) (Army Regulation (AR) 70-38, 1979). Soldier load continues to be a major stressor during combat execution and can be very heavy depending on the phase of mission. A study, conducted in 2003, of actual operations in Afghanistan indicated that soldiers in travelling phase of a mission carried, on average, 59.3 kg (131 lbs) and during fighting mode 28.5 kg (63 lbs) (Dean and Dupont, 2003).

Additional military unique characteristics may also include high altitude environments, nutritionally optimized cognitive and physical performance enhancements, and specific energy content, caloric density, and macro and micro nutrients to reduce the physiological strain associated with specialized mission requirements (Askew, 1996). Engineered ration components or supplemental items in the realm of performance enhancement are focused on various beneficial ingredients, compounds, nutraceutical products, targeted nutrient fortification and other mechanisms, to provide maximum metabolic benefit and counteract any degradation of combat capability, physical endurance and mental acuity.

Special purpose mission applications of ranger, light combat foot soldiers, and special operations units, for instance, involved in operations such as patrolling, reconnaissance, mountaineering, attack, ambush and raids are extremely stressful with periods of high intensity, near-continuous physical work, restricted sleep and limited periods for meals. Total energy cost expenditures for these types of sustained operations can reach extremely high levels, as soldiers are faced with sustained environmental exposure, fatigue, and sleep deprivation (Montain, 1995). Understanding combat stressors and devising effective intervention strategies to address these conditions through battlefield nutrition presents challenges as well as opportunities largely peculiar to the military. In many respects, nutrition is an essential combat multiplier.

Class I Supply Operations

Military field feeding systems, to include Joint Service and Service unique platforms, are designed to support the full range of battle doctrine by providing flexibility and options in feeding methods, rations, and equipment. This comprehensive approach ensures that the tactical commander's needs are met across the dimensions of operational and tactical mission objectives, the operational environment, and METT-TC factors. (The factors of mission, enemy, terrain and weather, troops and support available, time available, and civil considerations referred to simply as METT-TC, are situational variables that influence a commander's mission analysis and decision making. Consideration of feeding solutions is always condition-based.)It further provides commanders the capability and flexibility to deliver warfighters the *right meal, at the right place, and at the right time*, while providing a variety of options and agile, adaptive solutions that support sustained feeding operations in an expeditionary or tactical environment. This capability is critical to support a strategic force projection military that may be deployed anywhere globally on extremely short notice. This operational philosophy mandates field feeding operations that are highly mobile, rapidly deployable, responsive and flexible.

Common elements across all Service field feeding programs consist of the right mix of rations, equipment, personnel and training in order to support commanders in a broad range of military operations in all theaters, from small-scale contingencies to major combat operations as well as expeditionary maneuver warfare, operations other than war, and peacetime feeding or training requirements (FM 10-23, 1996). This feeding mission may be further expanded in specific situations to include support to joint, multinational or coalition forces and civilian populations when required, through the deployment of additional personnel and equipment. A range of containerized, trailer mounted, and modular tent-based field kitchen configurations and related food service equipment and system needs will vary based on Service unique operational missions, group feeding size, ration type, and a number of other critical factors. These systems will support storage, distribution, and preparation of a family of operational rations and menus. In the case of cook-prepared A-rations, that include both perishable and semi-perishable items, field kitchens will need to be augmented by transportation and material handling equipment assets, refrigerated transport and storage units, power generation equipment, fuel and water storage capability, washing and food sanitation centers, gray water disposal containers, and insulated food containers and beverage dispensers. The field feeding capability available will be dictated by the constraints of strategic mobility and tactical maneuver within a particular area, as well as the maturity of the supply and distribution channels and the operational tempo or pace of the engagement itself.

At the core of Class I operations is the ability to support and sustain deployed forces. This requirement may range from highly mobile field feeding capability that must support maneuver units including support to forward units or elements, infantry units or brigade combat teams, and heavy and light forces, to more static configurations. These static feeding requirements encompass modular, scalable base camp feeding in operational areas, such as large and often-well established base camps, Force Provider containerized tent cities, FOBs of several thousand soldiers or more, to smaller, emerging expeditionary base camps such as combat outposts (COPs) and patrol bases that are broadly dispersed within a region or area of responsibility (AOR). The smaller configurations ranging from platoon to company size and larger are often in isolated locations in forward positions. Food service equipment in these smaller camps or remote outposts may include containerized systems, man-portable, modular components used as built-up systems within buildings, or semi-fixed facilities and field expedient solutions. During the Global War on Terrorism in Afghanistan, units conducting operations in these austere and challenging environments must rely on frequent resupply of critical supplies and materiel over extended and unsecure supply lines across a variety of geographic areas and rugged terrain without distracting the unit's primary combat or counterinsurgency mission. Transport means run the gamut from combat logistics patrols (CLPs) with armed vehicle convoys, supply lines of host nation vehicles referred to as 'jingle trucks', and extensive use of air delivery options with frequent parachute drops (Government Food Service, 2010). Palletized bundles of food, water, engineering and other materials delivered from C-17 cargo aircraft, helicopter sling loads of needed supplies (Figure 1.2), and even use of primitive, yet effective, donkey and mule pack teams to more restrictive, isolated locations are common. Pack animals are used successfully to support operations in remote, extremely mountainous sections of Afghanistan to deliver water, ammunition, weapons and medical supplies in areas that are not serviced by roads and are otherwise unreachable by conventional transportation means.

FIGURE 1.2. *Deliveries of critical supplies to forward operations by helicopter sling load.*

This Class I capability is dependent on a number of key variables or factors, such as the maturity and development of the theater of operations and support infrastructure, availability of perishable and nonperishable subsistence and equipment assets within the supply system, adequate force structure to support the feeding mission, unique mission and employment tactics of deployed units, and appropriate air, sea and land transport and distribution assets. The intent in all of this is to provide an orderly, sustained pipeline for Class I supply and a range of options for optimal feeding methods that coincide with and support battlefield requirements and tactical opportunities without compromising feeding standards for warfighter nutrition, performance and morale. Class I operations and feeding systems must increasingly respond to operational demands and support all categories of military activity, providing both adaptability and versatility. This capability is necessary to cope with uncertainty and complexity of actions and conflict in an operational environment that is often joint, interagency and/or multinational in character.

Effective and coordinated planning and communication is essential to successful Class I operations in any theater of operations and must involve close coordination and interaction among logistical staff planners, the Theater Class I manager, key food service support agencies, Class I supply managers, the food service advisor, and food service personnel within the sustainment base organizational structure. Each of these elements plays a vital and active role in planning and implementing a feeding plan that supports operational plans as well as both mission and deployment criteria. Commanders must also rely on the experience and subject matter expertise of food service warrant officers and senior non-commissioned officers to both assess available feeding options and capabilities and also maximize effectiveness of the food service mission. Deployment of subsistence sustainment activities, including subsistence platoons and brigade support battalions, must ensure that the level of subsistence support and food service capability required is consistent with the theater ration cycle as well as the operational tempo, mission focus, and battle rhythm of supported units. It must provide units flexibility and be adaptive to an ever-changing environment and enemy (Pavek, 2005). Extensive and continuous coordination is needed at all levels of management and support to ensure Class I supplies, distribution, logistics and transportation capabilities, and equipment and personnel assets are available and synchronized with requirements for all military Services and supported allies within a theater.

Class I Distribution Systems

According to joint doctrine, distribution is the process of synchronizing all elements of the logistics system to deliver the 'right things' to the 'right place' at the 'right time' to support the combatant commander in an area of operations. The complexity and challenges of Class I supply and sustainment activities ramp up significantly during initial deployment to a theater. The inevitable challenges associated with ramp up of the production base, large supply demand, surge in troop strength, variable missions, unknown deployment durations, difficult terrain and weather, and massive strategic transport requirements are exacerbated by a logistics infrastructure and supply chain that is not yet fully mature. Use of demand prediction, on-time deliveries and metrics for flow times and order fill rates help to advance supply chain support, manage inventory and keep supplies moving. Even in a well-established operational theater, the sheer magnitude and volume of supplies that must be ordered, monitored and tracked, the extended order ship times for supplies, planning for seasonal demand fluctuation, and efficient management and distribution of numerous 20 and 40-foot container loads of Class I presents significant and near-overwhelming daily challenges (Brunson, 2004). These supplies must be continuously pushed out to forward support battalions, remote bases and dining facilities with supplies often managed globally by logisticians from the vendor to the foxhole. Efficient organization, management and control of Class I operations (Figure 1.3) in the deployment areas is a large and complex undertaking, requiring storage, rotation and redistribution of a large volume and diversity of supplies. It involves a continuous flow of perishable, semi-perishable, and shelf-stable food items, enhancements such as fresh fruit and vegetables, milk and bread, ice, and bottled water in a cascade of supplies that must be orchestrated smoothly in controlling movement of subsistence throughout the theater to ration break points to reach designated units.

The immense challenge associated with Class I distribution on the scale of magnitude of supporting operations in a major AOR is only one element of the overall military supply chain complexity across all commodities and classes of supply. Several key initiatives and actions have been undertaken by the DoD in recent years to address supply distribution problems dating back to the first Persian Gulf War that have impeded the ability of the DoD to provide effective and timely logistics support to the warfighter. Actions have been taken by the DoD to improve the food products, when aggregated over time, is a formidable amount of supply that must be moved within a specific area of operation. Competition for the movement of supplies is fierce, with fuel, water, ammunition, and other vital supplies taking high priority. Developing rations and field feeding systems that integrate locally available ingredients serves well in reducing the burden that rations place on the supply lines. But this presents enormous challenges in the areas of safety and quality. There is a need to provide integrated solutions that allow the field feeding system to capitalize on locally available food products and ingredients, while protecting the Warfighter from foodborne illness resulting from either a deliberate or non-deliberate act of food source contamination.

Develop Highly Efficient (Nutritionally Dense) Food Products and Rations

The very basic and primal purpose of a ration is to provide the Warfighter with the optimal nutrition to meet the physiological (and perhaps cognitive, to a lesser extent) demands of the missions he or she is engaged in. This presents challenges in certain operational contexts, due to the fact that the basic elements of food, the macronutrients, equate to a certain amount of weight and volume when integrated into a specific food or ration product. In order to achieve a specific level of caloric content in a food product, there are certain amounts of fat, protein, and carbohydrate that have to be incorporated to constitute the item with the substance required to deliver calories, etc. Additionally, rations are the platform to deliver the essential micronutrients (vitamins, minerals, etc.) that are necessary for the body to function properly. Micronutrients, due to the scant quantities required daily, are generally easier to physically incorporate into food items but do present challenges in shelf life and maintaining the organoleptic properties of the food product. Macronutrients add to the complexity of composite food matrices in a weight and space constrained scenario, and also have the same shelf life and organoleptic challenges as the micronutrients. There is a continuing and increasingly pronounced need to provide a family of ration products that are highly efficient in terms of the nutritional content with respect to weight and volume, while holding required shelf life and organoleptic properties constant. Doing so will result in highly nutritionally efficient ration products that reduce burdens on both the Warfighters and the logistics systems that support them.

Develop Food Products and Ration Packaging that Ease Meal Preparation Requirements at the Point of Consumption

The Joint Services are universally looking for ways of streamlining force structure and improving what is referred to as the "tooth to tail ratio" of the military force. Combatant Commanders have expressed an operational need to reduce the amount of the force engaged in support operations in relation to the number of personnel engaged in direct mission related activities. This is applicable as much for a U.S. Navy ship as it is for the land-based forces. What this means to the Joint Force Field Feeding Community is that there is a growing need to develop ration products and the requisite food preparation equipment that work together to reduce the amount of preparation and cleanup time required to feed the service members in a wide range of operational contexts. This challenge fits well with developments in the commercial food industry in the area of high quality, easy to prepare meals. These come in both shelf stable and non-shelf stable forms. While the non-shelf stable products offer menu options of remarkable quality, they do increase the demand for refrigeration systems on the battlefield. Refrigeration systems require power and maintenance, both of which burden the logistics systems supporting field feeding operations. Therefore, an emphasis on increasing the availability and variety of shelf stable, easy to prepare food products, augmented by non-shelf stable items, will provide higher quality meals with reduced preparation and logistics requirements.

Develop Transformational Food Products and Ingredients that Allow for Customization at the Point of Consumption

One way of tackling the need to reduce logistics burdens and food preparation requirements is to develop food products that offer flexibility in the form of menu/meal variation at the point of preparation. There is certainly a direct correlation between variety of rations available in the logistics systems and the burdens that those rations create within them. This is simply a reflection of the fact that the variety is created at the point of ration production and packaging. One way of reducing the logistics burdens without eliminating the variety is to push the point at which variety is created as far forward in the logistics system as possible. It should be obvious that this requires that the burdens of creating this variety are simply not just transferred forward which could, in some case, exacerbate the situation. It requires novel approaches to ration development, production, and packaging, so that the basic elements of food (ingredients that form the food matrices, etc.) remain elemental for as long as possible before being transformed into some specific food product.

Develop Food Processing and Preservation Processes that Facilitate Streamlining the Logistics Chain

As the demand for higher variety of high quality ration products increases, due in large part to cultural changes, the need to develop and implement novel means to stabilize food increases similarly. Without advanced food processing and preservation methods and techniques, the push to increase ration quality and variety will certainly result in an increase in demands on the logistics systems to include a need to increase battlefield conditioned storage capability. Therefore, there is a significant need to continue to advance novel methods to stabilize food. This includes many food items that have historically been omitted from military rations due to their respective incompatibilities with state of the industry food processing techniques, processes, and equipment. However, the obstacles to doing so are significant, given the capital investment required of the food industry to acquire, use, and maintain food production equipment.

CONCLUSION

One could call the challenges facing Warfighters in the future—considering the enormous pressure to decrease military logistics demands, and the rapidly changing eating habits of Americans—the perfect storm for the military field feeding community. Either one, taken on its own, presents challenges for those in the business of providing rations to the Warfighter. But together, they represent a challenge that will only be met through an aggressive, focused, and resourced research and development effort. The military field feeding community must work with its industry partners to exploit advances in food processing and preservation methods to provide a wider range of high quality food products with a maximum shelf life. The availability and range of shelf stable products should be at the center of these efforts, for they offer the greatest opportunity to improve military rations without further burdening the military logistics systems. A high degree of synchronicity among the rations, the food preparation equipment, and the food service personnel responsible for preparing and delivering rations to the Warfighter will ensure maximum logistics efficiencies throughout the entire supply chain, farm to fork.

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