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Microbiological Aspects of Certain Military Feeding Systems[1]

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ABSTRACT

There are various types of feeding systems within the military services. This paper considers the microbiological safety of those systems involved in feeding the military consumer in garrison, missile sites, and in the field with and without an organized kitchen. Since food readily supports growth of infectious and toxigenic microorganisms, comprehensive food service sanitation guidelines are provided which emphasize proper food preparation, storage, and serving. When such guidelines are not enforced by adequate and effective supervision, a combination of abuses may occur and present a potential microbial health hazard. Proper control of the microbiological quality of foods becomes even more important with centralized preparation. In a central preparation operation food is prepared for use at some future time. Therefore, if food is mishandled and growth conditions are presented to contaminating microorganisms, there is adequate time for multiplication. This could result in widespread food poisoning since foods prepared in a central preparation facility reach more consumers than with the usual kitchen operation. The importance of proper sanitation in the field feeding system cannot be overemphasized. In the field facilities are limited. However, every precaution must be taken to see that food is properly prepared, transported, and served and that the mess gear is sanitized. For field conditions where kitchens are not available, stable foods have been developed. Precooked dehydrated foods (food packet, long range patrol), thermally processed foods (meal, ready-to-eat, individual), and eventually radiation sterilized meats provide the consumer in the field with highly acceptable items which are microbiologically stable.

One of the earliest major contributions to improving a military feeding system was preservation of foods by use of heat and hermetically sealed containers, as demonstrated by Nicholas Appert. Such foods enhanced the provisions supplied to Napoleon's soldiers and helped in eliminating scurvy among sailors. Appert's work was published in 1810 and he was awarded 12,000 francs by the French government. He established his work on a commercial basis and it was eventually of major benefit to improvement of food distribution throughout the world. In the United States the military services have sponsored and performed research to improve military foods and feeding systems and to assure their microbiological safety. The basic principles and standards for food service sanitation prescribed to prevent food poisoning and foodborne infections in the military are essentially the same as those recommended by the U.S. Public Health Service in the Food Service Sanitation Manual (*2*). However, specific guidelines for each military service may be found in various manuals and regulations on food service operations, such as Army Regulation 40-5 (*4*).

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GARRISON FEEDING

The Army's food service is a world-wide operation with upwards of 1600 dining halls serving anywhere from less than 100 men to over a thousand, 7 days a week. In the present system each of possibly several dining halls at a particular site is designed to prepare a complete meal which is to be served within a few hours of preparation. All such military (e.g., Army, Air Force) feeding systems operate under regulations which stress the importance of careful control of time-temperature profiles, sanitation and personnel hygiene. Inspection findings showed that gross neglect of such regulations results in food of poor microbiological quality on the serving line. These inspections involve an evaluation of sanitation by visual inspection and by RODAC (replicate organism detection and counting) plates, monitoring of temperatures (e.g., storage, cooking, serving) and the microbiological quality of the foods on the serving line. RODAC plates, representing 25.8 cm^2 were used to determine the microbiological cleanliness of various food-contact sufaces. The number of plates used for an evaluation of the sanitation of a surface was related to the area under consideration (*9, 10*). 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.

When comparing two installations, designated A and T, it was evident that both showed some indifference to proper sanitation and temperature control on the serving line (Table 1). However, the sanitary state of food-contact surfaces was worse at installation T. The situation was further aggravated at T by several other poor practices. Frozen food was often thawed at room temperature, thermometers were not used to measure cooking temperatures and in comparison to A visually appeared unorganized and inefficient. The poor sanitation and organization at T, as compared to A was further emphasized by the microbiological quality of foods taken from the serving line (Table 2). Cooked foods were

TABLE 1. *Incidence of unsanitary food contact surfaces and noncompliance with serving temperature*

	Sanitary state of food-contact surfaces (RODAC)		Serving temperature	
	Garrison		Garrison	
	A	T	A	T
Number evaluated	14	64	54	21
Number unsatisfactory	3(21%)[a]	51(80%)[a]	32(59%)[b]	8(38%)[b]

[a]The percent of surfaces which did not comply with the following constraint: Half or more of the total number of RODAC plates used had 50 colony forming units (CFU) or less with none exceeding 100 CFU/25.8 cm^2.

[b]The percent of cooked foods failing to comply with a serving temperature $\geq$ 60 C.

sampled over a 3-4-day period and analyzed for total mesophilic aerobes, Most Probable Number (MPN) coliforms, and fecal coliforms. The determinations were essentially as described in the Food and Drug Administration's Bacteriological Analytical Manual (*1*) except that the diluent was 0.1% peptone and to determine the total aerobic count 0.1-ml aliquots of serial dilutions of the food homogenate were spread on prepared plate count agar. Fecal coliforms, as determined in this study, are comparable to *Escherichia coli* as described in the Microbiology Laboratory Guidebook, U.S. Department of Agiculture (*3*). The test enumerates organisms which have the ability to produce gas in EC broth at 45.5 C after preliminary selection in Bacto-lauryl tryptose broth.

Presence of large numbers of coliforms and the presence of fecal coliforms in those cooked foods taken from the serving line at installation T indicate a lack of good sanitary conditions and/or control of temperatures which could result in a health problem. In such a situation it is essential that management stress the importance of proper sanitation and food handling procedures and insist that an effective program be established. Adequate and effective supervisory effort plays an important role in providing the military consumer and the consumer, in general, with foods free from health hazards.

CENTRALIZED FOOD PREPARATION FACILITY (CFPF)

The Army has under consideration a centralized food preparation facility capable of supporting the serving of 25,000 meals per day in satellite dining halls (*5, 12*). In this system raw foods obtained from the commissary would be prepared in the CFPF and delivered to satellite dining halls. Precooked chilled or frozen entrees would be reconstituted and served in the dining hall. Salad ingredients would be prepared at the CFPF and mixed at the dining hall. Some items (e.g., roast beef) might go directly from the commissary to the dining hall for preparation and serving. This system would include central sanitation of all dishes and utensils used in the dining hall. The CFPF concept is a marked departure from the present system where each dining hall at a particular site is designed to prepare a complete meal which is to be served within a few hours of preparation. However, the central food preparation system is essentially a closed system wherein the microbiological quality of the foods can be closely monitored by trained personnel throughout the total system—storage, processing, distribution, preparation, and serving (*8*). If the total systems approach is taken, major emphasis is placed on raw materials, sanitation, time-temperature profiles, critical control areas, and not on the microbiological analysis of the finished product.

CENTRAL PREPARATION FOR MISSILE SITE FEEDING

At Warren Air Force Base in Cheyenne, Wyoming, is located a central production facility where raw products are cooked, portioned, packaged in foil, and quick frozen. Each frozen foil contains either an entree, starch, vegetable, or dessert. Therefore, a meal is made up of a grouping of foils. The frozen foil packs are distributed by refrigerated van over several states to Strategic Air Command bases which support missile sites. This base then distributes the frozen food to the missile site where the individual orders what he wishes to eat. The cook reconstitutes the food, plates the meal and supplements it with a fresh salad. Strategic Air Command (SAC) regulation 146-1 (Department of the Air Force, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska) outlines those conditions under which these foods must be prepared, stored, and distributed. The frozen items are considered to be microbiologically safe if the total aerobic, coliform and *E. coli* counts are $\leq$ 100,000, $\leq$ 100, and negative per gram. Any lot exceed-

TABLE 2. *Microbiological analysis of cooked foods*

	Garrison A			Garrison T		
	Counts			Counts		
Foods	Total aerobic (10^4 CFU/g)[a]	Coliforms (MPN/g)[b]	Fecal coliforms (MPN/g)[b]	Total aerobic (10^4 CFU/g)[a]	Coliforms (MPN/g)[b]	Fecal coliforms (MPN/g)[b]
Meat loaf	1.3	0	0	0.43	93	4
Roast beef	9.5	0	0	1.3	240	0
Ham	0.07	0	0	100	>1100	75
Chicken, fried	0.09	0	0	—	—	—
Chicken, baked	—	—	—	0.15	>1100	>1100
Potato, fried	—	—	—	200	>1100	150

[a]10,000 colony forming units (CFU) per gram.

[b]Most Probable Number per gram.

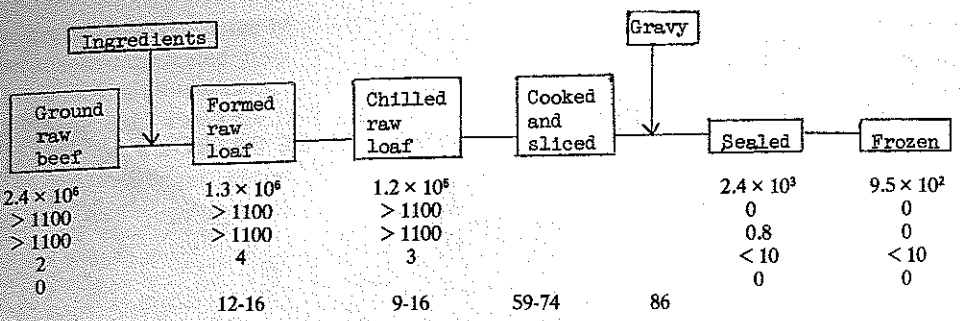

Figure 1. *The effect of processing on the microflora of meat loaf. Total aerobes, MPN coliforms and fecal coliforms per gram were determined as indicated in the section on garrison feeding. Fecal streptococci and MPN staphylococci per gram were determined according to the Food and Drug Administration's Bacteriological Analytical Manual using KF streptococcus agar and the MPN method, respectively. The latter test was modified as follows: 3 tubes of double-strength trypticase soy broth (TSB) were inoculated and incubated at 35 C for 2 h. Then single-strength TSB containing 20% NaCl was added to yield a final salt conc. of 10% and the tubes were incubated 48 ± 2 hr. at 35 C.*

ing either of these criteria is rejected and discarded. To insure a high degree of reliability in the procedures used to prevent a microbial health hazard, the U.S. Army Natick Development Center has initiated studies on the effects of processing on the microbiological quality of foods such as meat loaf (Fig. 1). The raw ground beef had over 1100 MPN fecal coliforms per gram. Cooking to an internal temperature of 59 to 74 C reduced the counts of total aerobes, coliforms, and fecal coliforms to acceptable levels. The fecal coliforms in the cooked meat loaf were detected, only because 1-g samples were used in the initial dilution. Baked and fried chicken cooked to internal temperatures of 77 to 88 C were free of coliforms, fecal coliforms, fecal streptococci, and staphylococci (data not shown). The microbiology of 10 processed foods is shown in Table 3. It is evident that the central production facility has the capability to process foods that are well within the microbiological constraints imposed by SAC-regulation 146-1. All 10 finished products had fewer than 10^3 CFU/g. Only two samples (country steak, O'Brien potatoes) contained coliforms, but fewer than 10 MPN/g. Meat loaf and country steak were the only foods that contained any fecal coliforms and in these two instances < 1 MPN/g. None of the samples contained any *Staphylococcus aureus* and all had fewer than 10/g of fecal streptococci.

TABLE 3. *Microbiological analysis of processed foods*

Foods	Total aerobes (10^2 CFU/g)[a]	Coliforms (MPN/g)[b]	Fecal coliforms (MPN/g)[b]
Pork chop suey	2.8	0	0
Roast pork	< 1.0	0	0
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

FIELD FEEDING

The Army mass feeding system in the field is normally set up to feed groups ranging in size from 100 to 250 individuals (company level). In the field the hot meals may be prepared in a tent or in a mobile field kitchen trailer. The meal may be served at the kitchen site or hot foods may be placed in insulated containers for transportation to sites within 15 miles and served. These containers are returned to the kitchen area for cleaning and sanitizing. As in other feeding systems, hot foods should be maintained and served at or above 60 C. Before being served each individual should sanitize the mess kit by dipping it in boiling water. Subsequent to eating, the mess gear must be cleaned and sanitized. The mess gear is scraped to remove leftovers, washed in warm (49-52 C) soapy water, rinsed in boiling water, and sanitized by a 1-min rinse in boiling water. Each mess kit sanitation line is supposed to accommodate 80 persons per meal and requires 240 gal. of water per day. It is important, but difficult to maintain the washing and rinsing solutions clean enough for proper efficiency.

A study is underway at the Natick Development Center to reduce the sanitation workload and requirements for water in the field to a minimum. Eventually the standard mess kit may be replaced by a disposable compartmented tray and eating utensils. If feasible, a disposable wipe may be provided for cleaning the canteen cup. Such an option would eliminate the need for sanitation lines at forward areas since the insulated containers are normally sanitized at the kitchen and would reduce the amount of water required. Also, the Natick Development Center is studying the feasibility of consolidating the Army Food Service system in the field so that up to 1000 troops may be fed from one kitchen area (*11*). Such a system would offer substantial savings both in manpower and costs.

For military operations away from organized field kitchens, it has been necessary to develop special meals which are stable under field conditions. The food packet, long-range patrol, was designed for troops in operations precluding resupply for periods up to 10 days (Fig. 2).

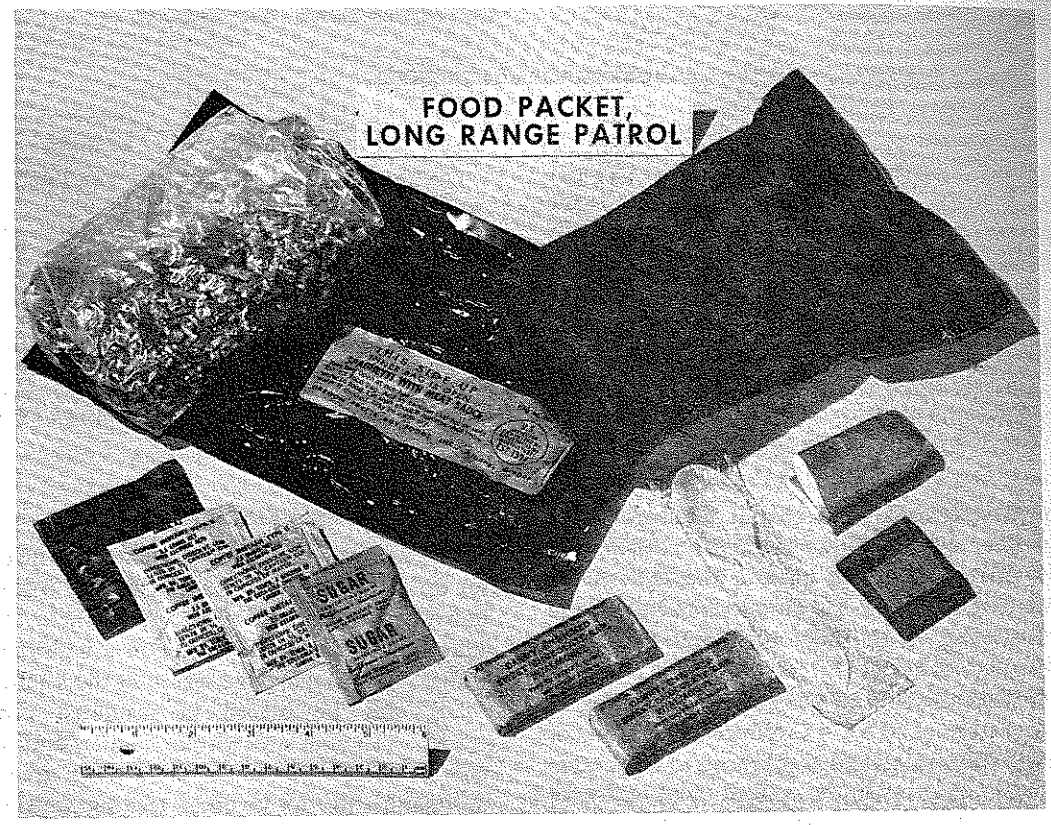

Figure 2. *Food packet, long range patrol—the first flexibly packaged combat ration. Components include a precooked freeze dehydrated main dish (spaghetti with meat sauce), cream substitute, coffee, sugar, two candy bars, or cereal or fruitcake bar, a plastic spoon, matches, and toilet paper. All components are contained within the waterproof barrier bag (upper right).*

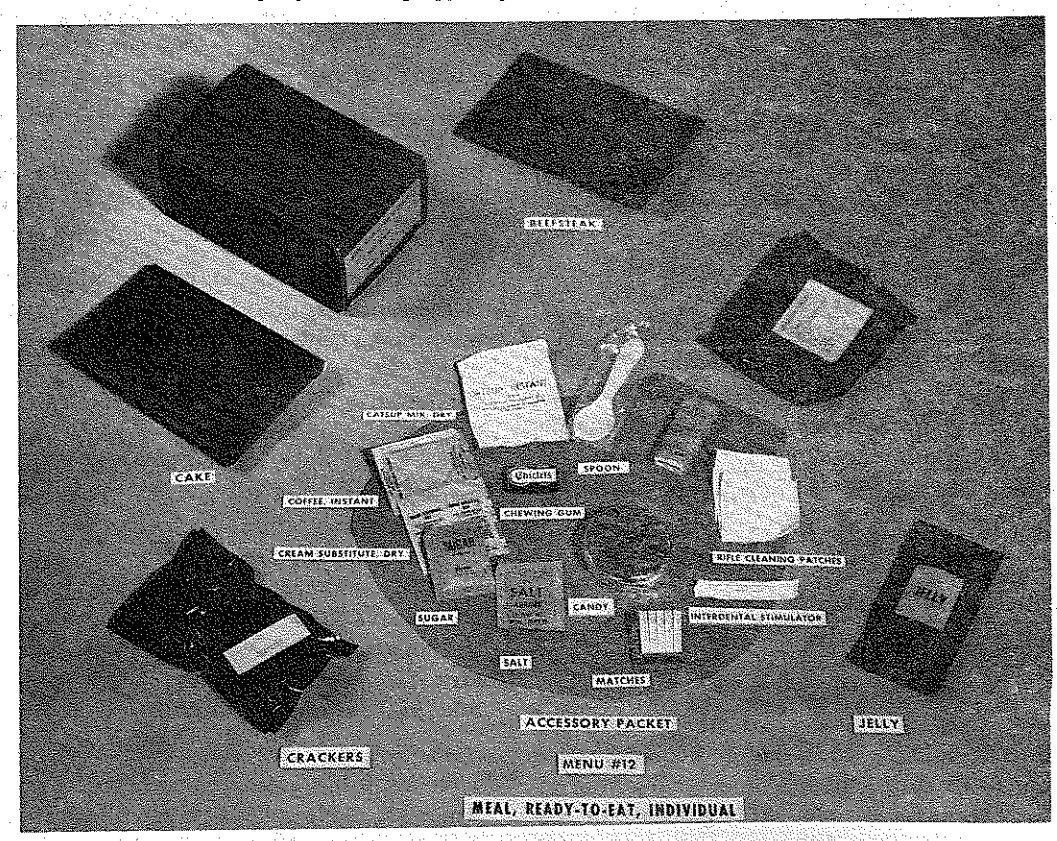

Figure 3. *Meal, ready-to-eat, individual. All components in the inner circle are contained within the flexible package to the right of the beefsteak. This package and all other items are contained within the paperboard carton (upper left).*

Note that lightweight packages are used in the place of cans. The main dish is a precooked dehydrated item (e.g., beef stew, chicken stew, beef hash, chili con carne) which may be rehydrated with hot or cold water for 5 min or eaten dry. Other food components include a confection, or cereal or fruitcake bar, and sugar. When produced, the precooked dehydrated foods must meet microbiological requirements of not more than 200,000 total aerobes and 40 coliforms per gram (*7*). Henderson et al. (*6*) showed that the total mesophilic aerobes per gram of rehydrated beef hash, chili con carne, spaghetti with meat sauce, beef with rice, chicken stew, pork with escalloped potatoes, beef stew, and chicken with rice were 190, 910, 11,000, 7,900, 14,000, < 1, 70, and 60 CFU/g, respectively. They did not detect any clostridia, coliforms, salmonellae, or staphylococci. The main microflora consisted of aerobic sporeformers, coagulase-negative micrococci, fecal streptococci in low numbers, yeasts, and molds. These products were designed to be consumed within a few hours of rehydration and are not to be saved for the following day. The meal, ready-to-eat, individual was recently developed for use under combat conditions where planned resupply is provided (Fig. 3). All of the food and nonfood components are packaged in lightweight flexible packages rather than cans. The "wet" meat components (e.g., beef steak, ham slices, ground beef with spice sauce, beef with gravy, chicken á la king,) cake (e.g. fruitcake), or cookies, or brownies and/or fruit (e.g., apple sauce, pineapple) are thermally processed and are commercially sterile. Also, the cakes have a water activity of approximately 0.85. Therefore, as long as the package is intact, this meal does not present any microbiological health hazard.

The military feeding systems are complex and do not always have the same fixed feeding location with all the fixed equipment. These feeding systems and foods are under constant review. Where deemed necessary the systems and foods undergo research and development to provide the military consumer, regardless of location or military situation, with food that is highly acceptable, nutritionally adequate, and free from health hazards.

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