Reprinted from FOOD TECHNOLOGY, Vol. 21, No. 10, Pages: 71–77

Acceptability of food items developed for Space Flight Feeding

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□ THE DEVELOPMENT and evaluation of dehydrated foods for use during space travel began in the early 1960's at Wright-Patterson Air Force Base (Taylor *et al.*, 1960).

The advent of the NASA Gemini and Apollo missions resulted in increased production and use of a variety of dehydrated foods. Approximately 100 food items have been tested in simulator studies to determine long term acceptability and nutritional adequacy.

It is necessary that as much knowledge as possible be obtained to develop an optimum spacecraft food management system that can provide acceptable food for varying flight durations and under stringent spacecraft conditions (Nanz *et al.*, 1967).

This paper will discuss a cross-sectional group of rehydratable foods and will review the organoleptic ratings these reconstituted items received under both laboratory and simulator study conditions. Bite-size foods, some of which are also dehydrated but which are not reconstituted prior to ingestion, will not be discussed.

In all cases, the acceptability data were collected using a nine-point hedonic scale with a midpoint of 5 (Peryam *et al.*, 1957).

Acceptability Studies

THE FOOD ITEMS to be compared throughout this paper are listed in Table 1 and shown in Fig. 1. The laboratory studies on these foods were performed by the U.S. Army Natick Laboratories. The acceptability of the food items was determined before and after storage for 3 and 6 months at 40°F, 70°F and 100°F (Hollender, 1963). The results of this study are tabulated in Table 2.

Cereals. The cereal products were commercial dry cereals and, in the case of the sugar frosted flakes, had been broken into smaller pieces to facilitate mixing. The products were combined with nonfat milk, sugar, and other ingredients in the dry state prior to packaging (Army Natick Labs., 1964h). Only one of the two products (oat cereal) was organoleptically less acceptable after 6 months' storage at 100°F.

Fruits and Vegetables. The fruits were freeze dehydrated using either fresh frozen or freshly canned products (Army Natick Labs., 1964f; 1964g). Both products showed deterioration with continuous exposure to 100°F for 3 and 6 months.

The laboratory results on the freeze-dehydrated vegetables were inconclusive for cream style corn and marginal for carrots with cream sauce even after being stored at 40°F for 3 months (Army Natick Labs., 1963a; 1963b; 1964j). These observations were early indications of the unpredictable nature of such products; further experience clearly demonstrated this problem, and this will be noted in subsequent tables.

Meats. The meats were all freeze-dehydrated items (Army Natick Labs., 1964a; 1964b; 1964c; 1964d; 1964e). With the exception of the bacon (Canadian bacon) with applesauce stored for 6 months at 100°F, all items were stable. The beef and chicken items without vegetables received better ratings than those which did contain vegetables.

Table 1. Test Food Items.

Cereal product	*Fruit product*
(1) Toasted oat cereal	(1) Fruit cocktail
(2) Sugar coated corn flakes	(2) Peaches

Vegetable product

(1) Carrots in cream sauce
(2) Cream style corn
(3) Green beans in cream sauce

Meat product	*Soup*
(1) Beef pot roast	(1) Corn chowder
(2) Beef with vegetables	(2) Mushroom
(3) Chicken with gravy	(3) Pea
(4) Chicken with vegetables	
(5) Bacon with applesauce	

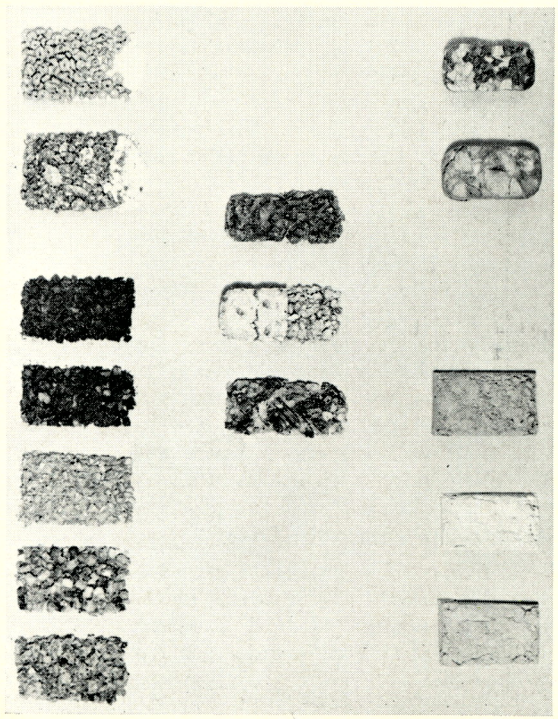

FIG. 1. *Selected samples of dried and freeze-dehydrated foods, arranged as indicated in Table 1.*

Table 2. Food preference[a] as affected by storage[b] (Hollender, 1963).

Storage temperature, °F Storage time, months	Before storage 0	40° 3	40° 6	70° 3	70° 6	100° 3	100° 6
	Preference ratings						
Cereal product							
(1) Toasted oat cereal	6.5	....	6.4	....	....	....	5.0
(2) Sugar coated corn flakes	6.15	....	6.5	....	....	....	6.3
Fruit product							
(1) Fruit cocktail	7.0	6.6	4.8	6.6	5.3	3.7	3.2
(2) Peaches	6.2	6.4	6.0	6.6	5.6	5.0	4.6
Vegetable product							
(1) Carrots with cream sauce	6.6	5.7	....	5.2	....	4.7	....
(2) Cream style corn	....	5.6	7.0	7.0	5.3	5.6	6.3
(3) Green beans with cream sauce	....	....	....	....	....	....	....
Meat product							
(1) Beef pot roast	6.5	6.4	6.9	6.4	6.0	6.8	6.6
(2) Beef with vegetables	6.3	6.2	6.1	6.0	5.6	6.0	....
(3) Chicken with gravy	7.1	6.7	5.7	7.1	6.4	6.8	5.9
(4) Chicken with vegetables	6.2	6.1	6.4	6.4	6.4	5.2	6.0
(5) Bacon with applesauce	6.1	5.9	5.7	6.7	6.0	5.9	5.1
Soup							
(1) Pea soup	6.0	5.5	5.7	....	....	5.7	6.0
(2) Mushroom soup	....	....	....	....	....	....	....
(3) Corn chowder	....	....	....	....	....	....	....

[a] Mean rating.
[b] Food packed in individual servings in standard 202 × 311 cans, sealed under 27-inch vacuum.

Soups. The soups were special formulations of dried ingredients (Army Natick Labs., 1964i). Only mushroom soup was evaluated, and it showed very little deterioration over 6 months.

Acceptability—Parallel Study

INITIAL EVALUATIONS of these foods were made during a 28-day confinement study (Senter, 1963) in which a total of 12 subjects, in groups of 3, subsisted on and rated a pre-cooked, dehydrated diet. Another 12 subjects, in the same environment and under identical conditions, subsisted on a dietetically matched menu of commercially available, heat-processed, fresh and frozen foods. The results of the study for the items under consideration are given in Table 3.

In general, *the control food items received slightly higher,* but not significantly higher, *hedonic scores than the specially processed test items eaten during the confinement.* Occasionally the converse was true, for example, peaches, and chicken with gravy. Two of the dehydrated test foods *failed completely* to be acceptable—carrots with cream sauce and Canadian bacon with applesauce.

Acceptability—Sequential Study

A SERIES of experiments was initiated in March 1963 for NASA by the 6570th Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base to determine the acceptance and nutritional adequacy of dehydrated foods reconstituted with room temperature water (as required during the Gemini missions). In two of these experiments (Speckmann *et al.*, 1965), four subjects were fed a nutritionally balanced 4-day cycle experimental menu of dehydrated and bite-size food for a period of 21 days. The experiment included a prior or subsequent feeding of a nutritionally and dietetically matched fresh-food menu for an additional 21 days.

The acceptance results of these experiments for the items under discussion are tabulated for comparison in Table 4.

It should be noted that the Wright-Patterson Air Force Base experiments (Speckmann *et al.*, 1965) confirmed and extended the data of Nunes *et al.* (1961) on the digestibility of dehydrated foods. A recent publication further describes the Wright-Patterson Air Force Base experiments and provides data on the acceptance and digestibility of dehydrated fods during a continuous 42-day metabolic study (Smith *et al.*, 1966).

The data in Table 4 demonstrate that **there was an individual dislike for** *carrots in cream sauce, pea soup,* and *mushroom soup.* However, **there is an actual preference for the** *dehydrated chicken with gravy* **when compared to the control fresh menu item.** All other test items received approximately the same ratings as the corresponding control item.

Acceptability Under Test Conditions

SINCE A SUPPLY of food is necessary during the testing of life-support systems, man-machine integrations, and habitability simulations, there are opportunities during these tests to collect acceptability data on various food items. In such studies, the number of subjects is often very small and usually no control diets can be fed. *The participants are frequently dis-*

Table 3. Food preference for fresh vs. dehydrated foods during 28-day confinement study (Senter, 1963).

Product	Control[a]	Test[b]	Differential
Cereal product			
(1) Toasted oat cereal	7.8	7.0	−0.8
(2) Sugar coated corn flakes	8.0	7.1	−0.9
Fruit product			
(1) Fruit cocktail	8.4	7.8	−0.6
(2) Peaches	7.6	8.2	+0.6
Vegetable product			
(1) Carrots with cream sauce	6.0	2.4	−3.6
(2) Cream style corn	6.4	5.6	−0.8
(3) Green beans with cream sauce	7.3	6.3	−1.0
Meat product			
(1) Beef pot roast	8.4	7.9	−0.5
(2) Beef with vegetables	7.9	7.5	−0.4
(3) Chicken with gravy	7.0	7.4	+0.4
(4) Chicken with vegetables	7.1	8.0	+0.9
(5) Bacon with applesauce	8.3	3.9	−4.3
Soup			
(1) Pea soup	....	....	
(2) Mushroom soup	5.8	4.4	−1.4
(3) Corn chowder	....	....	

[a] Fresh, frozen, or canned foods matched to test items.
[b] Food packed in individual servings in standard 202 × 311 cans, sealed under 27-inch vacuum.

interested in food evaluation because they are primarily concerned with the study of spacecraft systems. Food preferences reported as a result of two such studies are tabulated in Table 5.

The first study was a 30-day life-support system evaluation (National Aeronautics and Space Administration, 1964). *Two different dehydrated diets* were fed during this study but most of the items reported in the table were fed to five subjects for a total of 12 days only. The food for this study was processed in the fall and winter of 1962 and stored at 40°F until delivered to the study contractor in the early summer of 1963.

Because the initial manned test failed, the food was stored at room temperature until late October 1963, when it was again refrigerated until the test was reinstated in December 1963. Many of the items had undergone deterioration, ranging from marginal for fruit items and beef pot roast, to severe for vegetables.

Some of the individual food servings were vacuum packaged in prototype rehydratable food containers fabricated from a flexible transparent film laminate, while the remainder were vacuum packaged in aluminum foil laminate pouches. *The ratings for the food packaged in the transparent laminates were consistently poorer, reflecting the poorer protective barrier qualities of the packaging.*

The same four items (peaches, chicken with gravy, carrots with cream sauce and bacon and applesauce) were also incorporated into the menu of a more acceptable simulator diet served during the remaining phases (approximately 20 days) of the same life-support system test. The diet fed during the remainder of the simulator study included bread and coffee and allowed reconstitution of products with either hot or cold water.

With the exception of the bacon and applesauce, the four items received improved ratings under these conditions.

Data from the second study tabulated in Table 5 is from a 7-day performance reliability test conducted during 1964 under NASA contract. Three test pilots were the subjects and consumed a prototype flight-configured diet in which the items under discussion were included. All of the food servings were vacuum packaged in prototype rehydratable food containers fabricated from flexible transparent film laminate. Hot or cold water (as anticipated during the Apollo missions) was provided for reconstitution. All items except the vegetables and corn chowder received acceptable ratings under these conditions.

Table 4. Food preference for fresh vs. dehydrated foods in 42-day metabolic study [a] (Speckmann *et al.*, 1965).

Product	Control [b]	Test [c]	Differential
Cereal product			
(1) Toasted oat cereal	7.5	7.5	None
(2) Sugar coated corn flakes	7.5	7.5	None
Fruit product			
(1) Fruit cocktail	8.5	8.5	None
(2) Peaches	8.0	8.0	None
Vegetable product			
(1) Carrots with cream sauce	4.0	3.5	−0.5
(2) Cream style corn	....	....	.....
(3) Green beans with cream sauce	6.0	5.0	−1.0
Meat product			
(1) Beef pot roast	8.0	8.5	−0.5
(2) Beef with vegetables	7.0	7.5	+0.5
(3) Chicken with gravy	5.5	7.0	+1.5
(4) Chicken with vegetables	7.0	8.0	+1.0
(5) Bacon with applesauce	8.2	7.5	−0.7
Soup			
(1) Pea soup	5.0	3.7	−1.3
(2) Mushroom soup	5.0	4.5	−0.5
(3) Corn chowder	6.0	4.8	−1.2

[a] All foods served at room temperature.
[b] Fresh, frozen, or canned foods matched to test items.
[c] Test food packed in individual servings in aluminum foil laminate pouches, sealed under 27-inch vacuum.

Table 5. Food preference during simulator studies (precooked dehydrated food only).

Product	First study [a] NASA, 1964	Second study [b] Grodsky et al., 1966
Cereal product		
(1) Toasted oat cereal	5.3	6.5
(2) Sugar coated corn flakes	5.6	6.5
Fruit product		
(1) Fruit cocktail	(4.5)[c] 6.0 (6.7)[d]	7.3
(2) Peaches	6.7	6.3
Vegetable product		
(1) Carrots with cream sauce	2.0	2.0
(2) Cream style corn	....	....
(3) Green beans with cream sauce	2.9	1.5
Meat product		
(1) Beef pot roast	(5.3)[c] 6.1 (6.4)[d]	8.0
(2) Beef with vegetables	(4.8)[c] 5.4 (6.1)[d]	7.6
(3) Chicken with gravy	4.6	6.6
(4) Chicken with vegetables	4.8	5.5
(5) Bacon with applesauce	(4.0)[c] 5.3 (4.9)[d]	6.6
Soup		
(1) Pea soup	6.0	7.3
(2) Mushroom soup	6.1	8.0
(3) Corn chowder	4.0	3.3

[a] Reconstituted with room temperature water. Unless otherwise stated, food was vacuum packed in foil laminate pouches.
[b] Reconstituted with hot (150°F) or cold (50°F) water. Food was vacuum packed in prototype rehydratable food containers.
[c] Preference rating by some individuals when food item was vacuum packaged in prototype rehydratable food containers.
[d] Vacuum packaged in foil laminate pouches but eaten in conjunction with more acceptable menu providing hot and cold food and beverages.

The Findings—Total View

TABLE 6 presents a summary of the food preference ratings for the products listed in the tables presented earlier. The highest and lowest mean hedonic rating for each item evaluated either after storage or during actual use in simulation testing is presented. In general, *the items received initially higher hedonic ratings under* **field test conditions,** *and this may be*

Table 6. Summary by range[a] of food preference values presented in Tables 1 through 5.

Product	Laboratory (Hollender, 1963)	Simulation/Testing (Senter, 1963; Speckmann *et al.*, 1965/ NASA, 1964[c]; Grodsky *et al.*, 1966)	Remarks
Cereal product			
(1) Toasted oat cereal	6.5–5.0	7.8–5.3	Stable
(2) Sugar coated corn flakes	6.5–6.1	8.0–5.6	Stable
Fruit product			
(1) Fruit cocktail	7.0–3.2	8.5–6.0 (4.5)[b]	Stable
(2) Peaches	6.6–4.6	8.2–6.7	Stable
Vegetable product			
(1) Carrots with cream sauce	6.6–4.7	6.0–2.0	Rejected
(2) Cream style corn	7.0–5.3	6.4–5.6	Stable
(3) Green beans with cream sauce	.....	7.3–2.9	Rejected
Meat product			
(1) Beef pot roast	6.9–6.0	8.5–6.1 (5.4)[b]	Stable
(2) Beef with vegetables	6.3–5.6	7.5–5.4 (4.8)[b]	Stable
(3) Chicken with gravy	7.1–5.7	8.0–4.6	Stable
(4) Chicken with vegetables	6.4–5.2	8.0–4.8	Stable
(5) Bacon	6.7–5.1	7.5–3.9	Stable
Soup			
(1) Pea soup	.....	7.3–3.7	Marginal acceptance
(2) Mushroom soup	6.0–5.5	8.0–4.5	(especially without
(3) Corn chowder	.....	4.8–3.3	hot water)

[a] Highest and lowest rating received during all phases of experiments.
[b] Preference rating when food item was vacuum packaged in prototype rehydratable clear flexible film laminate food containers (ref. 21 only).
[c] 1964 Study by National Aeronautics and Space Administration.

a reflection of the small number and inexperience of the evaluators. However, the lowest ratings given are *remarkably similar* under *both* laboratory *and* field conditions.

Although collected under different conditions, the ratings have provided an opportunity to demonstrate the acceptability of food items. The laboratory testing provided a satisfactory *prediction* of eventual acceptability in most cases.

In addition, *it is believed that the ratings obtained in the tests*—when compared with the shelf life storage data—*serve as a qualitative index of ultimate shelf life.* With good packaging and low temperature storage, the shelf life of the items definitely exceeds 1 year. With few exceptions these products, if vacuum packaged in flexible pouches or cans with negligible water vapor and gas permeability characteristics, have at least a 6-month shelf life at 100°F.

There is little doubt that these items would be suitable for missions of extended duration.

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IN THE NEXT ISSUE. Next month *Food Technology* will present another article on man's endeavor to sever the need that keeps food a tether to terra firma. Steps leading to freedom of movement in outer space foodwise are indicated in the report of coordinated efforts to provide—for consumption in outer space—foods in suitable form, properly packaged, and nutritious and acceptable in quality.