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NUTRITIONAL EVALUATION OF A PRECOOKED DEHYDRATED AND BITE-SIZED COMPRESSED FOOD DIET AS SOLE SOURCE OF NUTRIMENT FOR SIX WEEKS

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AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
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WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This study was accomplished by the Biospecialties Branch, Physiology Division, Biomedical Laboratory, of the Aerospace Medical Research Laboratories, under contract with the Crew Systems Division, Manned Spacecraft Center, National Aeronautics and Space Administration (NASA), Houston, Texas; and in support of Project 7164, "Biomedical Criteria for Aerospace Flight," Task 716405, "Aerospace Nutrition." First Lieutenant Keith J. Smith, PhD, was principal investigator for the Air Force and Dr. Paul A. Lachance was the contract monitor for NASA. The investigation was originally proposed by First Lieutenants Paul A. Lachance and John E. Vanderveen, formerly of the Biospecialties Branch. Lieutenant Vanderveen was the principal investigator until he left service. Lt. Smith then assumed the duties of the principal investigator.

The following people are acknowledged for their extensive efforts in this investigation: Dr. Alton E. Prince, Chief of the Biospecialties Branch, and Dr. George Kitzes, Chief of the Physiology Division, for their administrative assistance; First Lieutenant Elwood W. Speckmann, PhD, in the areas of food and physiological measurement, and Miss Marilyn George for technical review (both of the Biospecialties Branch).

The biochemical analyses, subject selection and procurement, medical surveillance, and dietary assistance were provided by Miami Valley Hospital Research Department, Dayton, Ohio, under Contract AF 33(657)-11716, with Dr. R. E. Zipf as Director of Research and Dr. B. J. Katchman as Technical Administrator. The research covered by these contracts extends from August 1963 to June 1966.

This technical report has been reviewed and is approved.

WAYNE H. McCANDLESS
Technical Director
Biomedical Laboratory
Aerospace Medical Research Laboratories

ABSTRACT

A series of experiments has been designed to determine the water, energy, and protein requirements of man under various simulated aerospace conditions. The 42-day experiment reported herein was designed to evaluate nutritionally an experimental diet composed of precooked dehydrated and bite-sized compressed foods. Organoleptically, the experimental diet was highly acceptable. The food items did not become less acceptable after having been served repeatedly or a long period of time. The nutritional balance data show that the experimental diet was highly utilized and that it efficiently maintained the subjects for the duration of the experiment. The confinement of the subjects for 28 days in the Aerospace Medical Research Laboratories Life Support Systems Evaluator did not affect subject body weight, nutrient balance, digestion, or water balance. No abnormal hematological or physiological measurements were recorded as a result of subsisting on the experimental diet.

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SECTION I

INTRODUCTION

Diets composed of dehydrated and bite-sized compressed foods have been proposed for use in aerospace systems, because of their desirable volume and weight characteristics. Preliminary observations have shown that these foods are organoleptically acceptable (ref 16, 18, 19). Dehydrated and bite-sized compressed foods were compared with a matching diet composed of fresh, frozen, and heat processed foods in two 21-day experiments (ref 17). The results showed that these foods were organoleptically acceptable and would maintain man for that period of time without problems. However, it had not been determined that man could subsist for a period of 6 weeks on these foods.

SECTION II

METHODS

A 42-day nutritional balance study was conducted at the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. The subjects were four male college students selected after successfully completing a battery of physical, psychiatric, and microbiological examinations. The physical characteristics of the subjects are listed in table I. The subjects were monitored continuously and were required to maintain an activity schedule designed to provide periods of work, exercise, relaxation, and sleep (table II).

The subjects were confined to a controlled activity area for 7 days, were transferred to the Life Support Systems Evaluator for 28 days, and then were transferred back to the controlled activity area for a 7-day postexperimental period (table III). The living areas per man for the controlled activity area and Life Support Systems Evaluator were 9.0 and 2.0 square meters, respectively. Temperature was 22C and relative humidity was maintained at 50%.

Precooked dehydrated and bite-sized compressed foods were arranged into a nutritionally balanced 3-day cycle menu with four meals per day (table IV). The organoleptic quality of each food item was rated after each meal by each subject using a nine-point graduated scale (table V).

The menus were prepared and/or reconstituted with room temperature water (24 $\pm$3C) and were served at room temperature. All food served to the subjects was accurately weighed ($\pm$0.5 grams). The subjects were required to eat all food provided. No additional food or condiments were permitted. Water was consumed *ad libitum* but individual intakes were accurately measured. The amount of metabolic water produced by the body was calculated by the method of Consolazio (ref 2). This formula takes into consideration the amounts produced by the oxidation of the protein, fat, and carbohydrate. The water excreted in the urine and feces was deducted from the water ingested plus the metabolic water to obtain "available water," which indicates the amount of water available for excretion as insensible water loss and as sweat, assuming water balance is maintained.

Twice during each experiment, an analysis was done on each individual menu served. The analyses included determinations for moisture (ref 8), nitrogen (ref 6), fat (ref 7), cellulose (ref 10), ash (ref 7), energy (ref 14), calcium (ref 13), phosphorus (ref 15), sodium (ref 5), potassium (ref 5), and chloride (ref 11). The amount of carbohydrate was calculated as the difference between total sample weight and the weight of moisture, crude protein, fat, cellulose, and ash.

Individual stool samples were pooled on the days shown in table III. The pooled samples were homogenized, freeze-dried and analyzed in duplicate for moisture (ref 8), total nitrogen (ref 4), fat (ref 9), cellulose (ref 10), ash (ref 7), calcium (ref 13), phosphorus (ref 15), sodium (ref 5), potassium (ref 5), and total energy (ref 14).

The volumes of all 24-hour urine collections were recorded and specimens were pooled into 72 hour samplings for analysis. These 72-hour samples were frozen and stored in a freezer until analyzed. Urine samples were analyzed for total nitrogen (ref 4), creatine (ref 1), calcium (ref 13), phosphorus (ref 15), sodium (ref 5), potassium (ref 5), chloride (ref 12), and total energy (ref 14).

The total fecal and urinary excretion of the various nutrients were determined for each experimental period. These data plus the food analyses data were used to calculate nutri-

ent digestibility and balance. Balance was computed by subtracting the total output of a given constituent excreted in urine and feces from the total dietary intake of that constituent. The coefficients of apparent digestibility were calculated by subtracting the fecal excretion from the dietary intake and determining the percent of total intake absorbed and utilized.

TABLE I

PHYSICAL CHARACTERISTICS

Subject No.	*Age years*	*Weight*		*Height*	
		kg	*lb*	*cm*	*in.*
21	21	60.0	132	170	67
22	22	70.1	154	178	70
23	24	79.9	176	173	68
24	21	86.8	191	170	67

TABLE II

SUBJECTS' DAILY SCHEDULE

Time	Subjects 21	Subjects 22	Subjects 23	Subjects 24	Time
0730	Wake, Void, Medical Measurements. Pass into chamber. Sample for personal hygiene and return samples to laboratory.				0730
0900					0900
1000	Eat Meal A				1000
1100	Psychological Testing (22)				1100
1200	Exercise (21)				1200
1300	Eat Meal B		Sleep		1300
1400	Psychological Testing (21)				1400
1500	Exercise (22)				1500
1600	Free Time and Baralyme Transfer				1600
1700	Eat Meal C				1700
1800					1800
1900					1900
2000	Free Time and Exercise				2000
2100	Eat Meal D		Eat Meal B		2100
2200					2200
2300					2300
2400	Sleep		Free Time		2400
0100			Eat Meal C		0100
0200			Free Time		0200
0300			Psychological Testing (24)		0300
0400			Exercise (23)		0400
0500			Eat Meal D		0500
0600			Psychological Testing (23)		0600
0700			Exercise (24)		0700
0730					0730

TABLE III

EXPERIMENTAL DESIGN

Experimental Day	*Environment (Period)*	*Menu*	*Blood Collection*	*Urine*	*Feces*
1	Controlled Activity Area Prechamber (7 days)	1		U1	F1
2		2			
3		3	X		
4		1			
5		2		U2	F2
6		3	X		
7		1			
8	Evaluator Chamber (28 days)	2		X	X
9		3		U3	F3
10		1			
11		2			
12		3	X		
13		1		U4	
14		2			
15		3	XX		
16		1		U5	F4
17		2			
18		3	X		
19		1		U6	
20		2			
21		3	XX	U7	
22		1			
23		2			
24		3	X		
25		1		U8	F5
26		2			
27		3			
28		1		U9	
29		2			
30		3	XX		
31		1		U10	
32		2			
33		3	X		F6
34		1		U11	
35		2			
36		3	XX	X	
37	Controlled Activity Area (7 days) Postchamber (7 days)	1		U12	F7
38		2			
39		3	X		
40		1			
41		2		U13	F8
42		3	X		

TABLE IV

METABOLIC DIET*

THREE-DAY CYCLE MENUS

Menu No. 1	*Weight* g	*Carbohydrate* g	*Protein* g	*Fat* g
Meal A				
Apricot Cereal	37.0	25.5	3.1	6.1
Apple Juice	180.0	25.2	0.1	Trace
Sausage	124.0	2.8	20.9	13.1
Cinnamon Toast	11.4	7.0	1.1	2.8
Fruit Cocktail	106.0	20.5	0.6	Trace
Total	458.4	81.0	25.8	22.0
Meal B				
Toast Bread Cubes	35.5	20.1	5.3	7.4
Chicken/Gravy	109.0	8.6	12.6	1.1
Pineapple Cubes	35.0	20.9	4.1	8.4
Cocoa	182.0	31.8	3.1	5.1
Total	361.5	81.4	25.1	22.0
Meal C				
Toast	23.8	11.9	4.0	6.8
Tuna Salad	79.5	3.3	19.5	11.6
Apricot Pudding	182.0	61.4	1.3	4.9
Tea	148.0	7.7	0.1	Trace
Total	433.3	84.3	24.9	23.3
Meal D				
Beef/Vegetables	109.5	6.9	14.3	2.0
Orange-Grapefruit Juice	175.0	18.8	1.2	Trace
Potato Salad	81.5	8.1	6.0	9.8
Toast	9.5	4.7	1.6	2.7
Date Fruit Cake	66.9	42.3	2.9	8.1
Total	442.4	80.8	26.0	22.6
Daily Total	1695.6	327.5	101.8	89.9
Total Calories	2526			

*Calculated Values.

TABLE IV (Continued)

METABOLIC DIET*

THREE-DAY CYCLE MENUS

Menu No. 2	*Weight* g	*Carbohydrate* g	*Protein* g	*Fat* g
Meal A				
Pineapple Juice	182.0	26.5	0.6	Trace
All Star Cereal	108.0	18.7	3.5	0.2
Bacon & Egg Bites	26.0	1.1	8.9	15.0
Beef Sandwich	16.8	3.6	9.5	2.5
Cocoa	182.0	31.8	3.1	5.1
Total	514.8	81.7	25.6	22.8
Meal B				
Beef Bites	24.5	3.0	15.6	0.6
Potato Salad	81.5	8.1	6.0	9.8
Toast	12.7	6.3	2.1	3.6
Chocolate Pudding	182.0	54.7	2.7	9.2
Tea	148.0	7.7	0.1	Trace
Total	448.7	79.8	26.5	23.2
Meal C				
Grapefruit Juice	175.0	18.9	1.0	Trace
Chicken Bites	28.5	1.7	17.7	6.2
Potato Chip Blks	32.3	25.9	2.7	1.2
Peaches	104.0	17.9	1.0	Trace
Brownies	38.8	18.0	3.0	14.8
Total	378.6	82.4	25.4	22.2
Meal D				
Potato Soup	189.0	34.3	2.8	8.2
Shrimp Cocktail	86.0	9.6	15.9	1.6
Toast Bread Cubes	53.3	30.2	8.0	11.2
Tea	148.0	7.7	0.1	Trace
Total	476.3	81.8	26.8	21.0
Daily Total	1818.4	325.7	104.3	89.2
Total Calories	2523			

*Calculated Values.

TABLE IV (Concluded)

METABOLIC DIET*

THREE-DAY CYCLE MENUS

Menu No. 3	*Weight* g	*Carbohydrate* g	*Protein* g	*Fat* g
Meal A				
Orange-Pineapple Juice	178.0	23.1	1.0	Trace
Sugar Fr. Flakes	120.8	31.3	3.4	0.1
Bacon Squares	15.0	1.9	7.9	3.5
Peanut B. Sandwich	34.4	10.2	10.8	11.8
Apricot Cubes	28.4	16.4	3.5	7.3
Total	376.6	82.9	26.6	22.7
Meal B				
Salmon Salad	123.0	0.7	19.2	16.6
Potato Chip Blks	32.2	25.9	2.7	1.2
Applesauce	168.0	40.5	0.3	0.2
Pound Cake	18.1	9.8	1.5	5.0
Tea	148.0	7.7	0.1	Trace
Total	489.4	84.6	23.8	23.0
Meal C				
Grape Juice	181.0	25.7	0.5	Trace
Chicken/Vegetables	109.0	3.7	17.6	1.4
Toast	19.0	9.4	3.2	5.4
Pineapple Fruitcake	78.8	44.3	5.0	15.4
Total	387.8	83.1	26.3	22.2
Meal D				
Spaghetti/Meat	105.0	6.2	9.9	2.9
Cheese Sandwich	33.8	6.8	15.0	10.1
Butterscotch Pud.	182.0	58.2	1.2	7.8
Tea	148.0	7.7	0.1	Trace
Total	468.8	78.9	26.2	20.8
Daily Total	1722.6	329.5	102.9	88.7
Total Calories	2528			

*Calculated Values.

TABLE V

NINE-POINT FOOD ACCEPTABILITY 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

SECTION III

RESULTS AND DISCUSSION

The food acceptability ratings of the dehydrated and bite-sized compressed food items comprising the diet are presented in table VI. The food items were highly acceptable as indicated by the subjects' ratings and comments. Food items receiving lower average ratings were a reflection of personal dislikes by one subject. Minimal variation was observed between menu and meal (table VII). No evidence of food monotony was observed with repeated servings.

During two previous joint USAF/NASA nutritional studies, a 4-day cycle menu diet composed of precooked dehydrated and bite-sized foods from the same case lots used in this experiment were given to eight subjects for 21 days. The average combined acceptability ratings for the two experiments were 7.4 and 5.9 (ref 17). The 3-day cycle menu used in this experiment was established by eliminating the food items that were rated low in acceptability in the previous two experiments, and food items that, because of their nutrient composition, could not be worked into the nutritionally balanced menus. The resultant diet was rated organoleptically superior to the 4-day cycle diet and to a 4-day cycle diet of fresh foods served for 42 days under similar environmental conditions as experienced in this experiment (ref 18).

Table VIII gives the subject body weight change during the prechamber, chamber, and postchamber experimental periods. The slight subject weight loss can be attributed to insufficient dietary energy provided. These results are similar to earlier results (ref 17) obtained in the joint USAF/NASA nutritional balance experiments. Under the conditions of the reported experiments, approximately 38 kcal energy is needed per kg body weight to eliminate body weight change.

Menu analyses are shown in table IX. The diet contained an average of 115.7 g crude protein, 89.5 g fat and 280 g carbohydrate. The 2660 kcal of energy contained in the diet were derived from protein (19%), fat (35%), and carbohydrate (46%). The slight variation between calculated and analyzed nutrient amounts can be attributed to the values used for the calculation of theoretical dietary composition.

The nitrogen balance and apparent digestibility data are presented in table X. The data show that an average of 18.5 g nitrogen was consumed daily, and an average of 14.2 g excreted daily, 1.6 g in the feces and 12.6 in the urine. The 4.3 g difference kept the subjects in positive nitrogen balance. Consolazio (ref 2) has reported that up to 2 g nitrogen may be lost daily in body sweat. The balance experiments reported herein did not measure whole body sweat. The Food and Nutrition Board (ref 3) recommends that at least 1.0 g of crude protein per kg body weight be supplied. Since the nitrogen intake (crude protein = N X 6.25) was greater than this recommended level, it is not surprising that the subjects were in positive nitrogen balance.

The higher fecal nitrogen excretion value for subject 21 during the prechamber experimental period is probably not real and was due to either a longer period of time to adjust to the experimental diet or to a sampling error.

The experimental period did not affect energy balance or digestibility (table XI). The dehydrated and bite-sized compressed food diet provided was efficiently absorbed and assimilated as indicated by the 94.2% apparent digestibility.

The data indicated normal variation in fat digestibility between experimental periods (table XII). When a matching fresh diet was served for the same length of time (ref 18),

an apparent digestibility of 98.0% was observed. Caution should be used in making comparisons between experiments using different subjects. However, the digestibility of the experimental diet appears to be slightly lower than a fresh matching diet. This observation may be due in part to the high fat content of the bite-sized food items.

Water balance data are given in table XIII. All values fell in the normal, accepted ranges. Therefore, it can be concluded that the experimental diet of dehydrated and bite-sized compressed foods did not alter water requirements.

Sodium, potassium, and chloride balances are shown in tables XIV, XV, and XVI. The experimental period had no effect on mineral balance.

Tables XVII and XX present the blood component analyses. The experimental period did not affect any of the blood components measured. All values fell in the normal ranges for normal healthy subjects.

Based on the results of the 42-day nutritional balance study, the following conclusions are drawn: (1) the experimental diet of precooked dehydrated and bite-sized compressed foods were highly acceptable over the 42-day period and there was no evidence of food monotony; (2) the nutritional balance data indicated that the experimental foods were efficiently utilized by the human organism; (3) the experimental periods (prechamber, chamber, and postchamber) had no effect on nutrient balance; (4) approximately 38 kcal per kg body weight are needed, under the condition of this experiment, to maintain body weight of a 70 kg man; (5) a diet containing 18.5 g nitrogen (115.7 g crude protein) is sufficient to maintain subjects in positive nitrogen balance; (6) neither the diet nor the experimental period affected blood components.

TABLE VI

FOOD ACCEPTABILITY

Menu No. 1*	Subject Averages				Combined Averages
	21	22	23	24	
Meal A					
Apricot Cereal	4.0	7.8	7.7	8.3	7.0
Apple Juice	7.9	8.2	8.9	8.9	8.5
Sausage	5.7	7.6	8.8	8.9	7.8
Cinnamon Toast	7.3	8.4	8.7	8.6	8.3
Fruit Cocktail	7.1	8.9	8.7	8.5	8.3
Meal B					
Toast Bread Cubes	7.5	7.5	8.3	6.9	7.6
Chicken/Gravy	7.9	7.6	8.9	8.6	8.3
Pineapple Cubes	1.4	7.0	8.4	7.7	6.1
Cocoa	7.3	7.3	8.9	8.7	8.1
Meal C					
Toast	7.9	8.4	7.9	7.3	7.9
Tuna Salad	8.0	8.8	8.8	8.6	8.6
Apricot Pudding	1.1	8.4	8.4	8.4	6.6
Tea	8.1	7.3	8.9	8.7	8.3
Meal D					
Beef/Vegetables	7.8	7.9	8.6	8.6	8.2
Orange-Grpfrt. Juice	7.9	8.2	9.0	8.7	8.5
Potato Salad	5.9	6.9	7.9	8.6	7.3
Toast	7.9	7.3	7.9	7.3	7.6
Date Fruitcake	7.6	6.6	7.6	8.6	7.6

*Acceptability based on nine-point grading scale (Table V).

TABLE VI (Continued)

FOOD ACCEPTABILITY

Menu No. 2*	Subject Averages				Combined Averages
	21	*22*	*23*	*24*	
Meal A					
Pineapple Juice	8.0	8.1	8.9	8.6	8.4
All Star Cereal	4.5	7.3	7.9	8.6	7.1
Bacon & Egg Bites	4.4	7.1	7.7	7.3	6.6
Beef Sandwich	7.9	6.9	8.4	7.4	7.7
Cocoa	7.2	7.3	8.9	8.6	8.0
Meal B					
Beef Bites	7.9	7.4	8.5	7.5	7.8
Potato Salad	6.2	6.7	7.7	8.5	7.3
Toast	7.9	7.6	7.5	6.6	7.4
Chocolate Pud.	6.5	8.9	8.9	8.6	8.2
Tea	8.0	7.1	8.9	8.7	8.2
Meal C					
Grapefruit Juice	7.9	8.7	8.9	8.6	8.5
Chicken Bites	8.1	8.4	8.4	7.6	8.1
Potato Chip Blks.	8.1	8.4	8.1	8.4	8.3
Peaches	7.9	8.9	8.9	8.7	8.6
Brownies	7.9	8.9	7.9	8.7	8.4
Meal D					
Potato Soup	8.0	8.6	6.6	6.9	7.5
Shrimp Cocktail	8.1	8.7	5.5	6.4	7.2
Toast Bread Cubes	7.9	8.5	6.0	6.3	7.2
Tea	8.0	7.6	8.9	8.6	8.3

*Acceptability based on nine-point grading scale (Table V).

TABLE VI (Continued)

FOOD ACCEPTABILITY

Menu No. 3*	Subject Averages				Combined Averages
	21	22	23	24	
Meal A					
Orange-Pineapple Juice	8.0	8.3	8.9	8.7	8.5
Sugar Fr. Flakes	4.6	7.4	8.1	8.5	7.2
Bacon Squares	7.6	7.4	8.9	8.9	8.2
Peanut B. Sandwich	6.4	7.7	7.9	8.1	7.5
Apricot Cubes	1.6	7.7	7.4	7.6	6.1
Meal B					
Salmon Salad	8.0	8.5	8.7	8.5	8.4
Potato Chip Blks.	8.0	8.4	8.4	8.4	8.3
Applesauce	7.9	8.8	8.5	8.6	8.5
Pound Cake	7.9	8.9	8.4	8.4	8.4
Tea	8.0	7.3	8.9	8.6	8.2
Meal C					
Grape Juice	8.0	8.6	8.3	9.0	8.5
Chicken/Vegetables	8.0	7.6	7.3	8.5	7.9
Toast	8.0	7.4	7.3	6.9	7.4
Pineapple Fruitcake	7.9	6.9	7.9	8.5	7.8
Meal D					
Spaghetti/Meat	8.0	6.9	8.9	8.7	8.1
Cheese Sandwich	7.8	6.6	7.8	7.6	7.5
Butterscotch Pud.	8.2	9.0	9.0	9.0	8.8
Tea	8.0	7.4	8.9	8.6	8.2

*Acceptability based on nine-point grading scale (Table V).

TABLE VII

SUMMARY OF FOOD ACCEPTABILITY*

Meal	*Menu Number*			*Average Meal Acceptability*
	1	*2*	*3*	
A	8.0	7.6	7.5	7.7
B	7.5	7.8	8.4	7.9
C	7.9	8.4	7.9	8.1
D	7.8	7.6	8.2	7.9
Average Diet Acceptability	7.8	7.9	8.0	
Combined Diet Acceptability				7.9

*Acceptability values presented are derived from table VI.

TABLE VIII

BODY WEIGHT CHANGE*

Condition	*Interval (days)*	*Subject No.*	*Weight (kg)*		
			Initial	*Final*	*Change*
Prechamber	7	21	60.4	59.3	−1.1
		22	70.2	69.4	−0.8
		23	79.9	79.2	−0.7
		24	87.3	85.8	−1.5
Chamber	28	21	59.3	59.1	−0.2
		22	69.4	70.6	1.2
		23	79.2	79.3	0.1
		24	85.8	84.8	−1.0
Postchamber	7	21	59.1	58.9	−0.2
		22	70.6	70.1	−0.5
		23	79.3	79.5	0.2
		24	84.8	84.4	−0.4
Combined Averages					
Prechamber					−1.0
Chamber					0.0
Postchamber					−0.2

*Values presented as 3-day weight averages.

TABLE IX

FOOD ANALYSIS

Constituent	*Units*	*Menu 1*	*Menu 2*	*Menu 3*
Sample Weight	g	1730	1788	1640
Moisture	%	69.7	70.9	68.8
Dry Weight	g	524	522	512
Nitrogen	g	19.3	19.1	17.1
Protein	g	120.5	119.6	107.0
Fat	g	89.9	89.4	89.2
Cellulose	g	6.1	7.2	5.7
Ash	g	34.6	27.8	20.5
Carbohydrate*	g	272.9	277.6	289.6
Sodium	g	4.80	4.21	4.45
Potassium	g	3.26	4.32	2.85
Chloride (as NaCl)	g	11.7	10.2	10.8
Energy	kcal	2680	2700	2610
Fat	%	17.2	17.1	17.4
Carbohydrate	%	52.1	53.2	56.6
Protein	%	23.0	22.9	20.9

*Analysis by difference

TABLE X

NITROGEN BALANCE

Condition	*Subject No.*	*Intake g/24 hrs*	*Excretion g/24 hrs*			*Balance g/24 hrs*	*Apparent Digestibility %*
			Feces	*Urine*	*Total*		
Prechamber	21	18.5	2.9	13.4	16.3	2.2	84.3
	22	18.5	1.5	10.8	12.3	6.2	91.9
	23	18.5	1.3	13.7	15.0	3.5	93.0
	24	18.5	1.2	15.0	16.2	2.3	93.5
Chamber	21	18.5	1.6	12.8	14.4	4.1	91.4
	22	18.5	1.3	11.4	12.7	5.8	93.0
	23	18.5	1.5	12.0	13.5	5.0	91.9
	24	18.5	1.8	12.8	14.6	3.9	90.3
Postchamber	21	18.5	1.6	11.6	13.2	5.3	91.4
	22	18.5	1.3	14.7	16.0	2.5	93.0
	23	18.5	1.5	9.8	11.3	7.2	91.9
	24	18.5	1.5	13.2	14.7	3.8	91.9
Condition Averages							
Prechamber		18.5	1.7	13.2	14.9	3.6	90.7
Chamber		18.5	1.6	12.3	13.9	4.6	91.7
Postchamber		18.5	1.5	12.3	13.8	4.7	92.1
Overall Average							
		18.5	1.6	12.6	14.2	4.3	91.5

TABLE XI

ENERGY BALANCE

Condition	*Subject No.*	*Intake kcal/24 hr*	*Undigested kcal/24 hr*	*Digested kcal/24 hr*	*Excreted Urine kcal/24 hr*	*Metabolizable Energy kcal/24 hr*	*Apparent Digestibility %*
Prechamber	21	2660	214	2446	121	2325	92.0
	22	2660	149	2511	107	2404	94.4
	23	2660	117	2543	114	2429	95.6
	24	2660	137	2523	134	2389	94.8
Chamber	21	2660	165	2495	118	2377	93.8
	22	2660	147	2513	102	2411	94.5
	23	2660	120	2540	115	2425	95.5
	24	2660	197	2463	125	2338	92.6
Postchamber	21	2660	159	2501	113	2388	94.0
	22	2660	147	2513	106	2407	94.5
	23	2660	129	2531	105	2426	95.2
	24	2660	177	2483	131	2352	93.3
Condition Averages							
Prechamber		2660	154	2506	119	2387	94.2
Chamber		2660	157	2503	115	2388	94.1
Postchamber		2660	153	2507	114	2393	94.2
Overall Average							
		2660	155	2505	116	2389	94.2

TABLE XII

FAT DIGESTIBILITY

Condition	*Subject No.*	*Intake g/24 hr*	*Excretion g/24 hr Feces*	*Apparent Digestibility %*
Prechamber	21	89.5	7.0	92.2
	22	89.5	5.5	93.9
	23	89.5	2.7	97.0
	24	89.5	4.1	95.4
Chamber	21	89.5	5.5	93.9
	22	89.5	6.4	92.8
	23	89.5	4.0	95.5
	24	89.5	8.9	90.1
Postchamber	21	89.5	4.5	95.0
	22	89.5	7.1	92.1
	23	89.5	3.3	96.3
	24	89.5	7.8	91.3
		Condition Averages		
Prechamber		89.5	4.8	94.6
Chamber		89.5	6.2	93.1
Postchamber		89.5	5.7	93.7
		Overall Average		
		89.5	5.6	93.8

TABLE XIII

WATER BALANCE

Condition	*Subject No.*	*Water Available ml*				*Water Excreted ml*			*Water Available for Evaporation (Assuming Water Balance) ml*
		Dietary	*Ad lib*	*Metabolic*	*Total*	*Urine*	*Feces*	*Total*	
Prechamber	21	1200	1622	291	3113	1661	158	1819	1294
	22	1200	627	286	2113	864	50	914	1199
	23	1200	722	296	2218	1091	40	1131	1087
	24	1200	713	301	2214	1123	48	1171	1043
Chamber	21	1200	1241	291	2732	1601	58	1659	1073
	22	1200	476	286	1962	860	43	903	1059
	23	1200	320	290	1810	971	45	1016	794
	24	1200	395	287	1882	970	80	1050	832
Postchamber	21	1200	840	289	2329	961	48	1009	1320
	22	1200	465	294	1959	905	35	940	1019
	23	1200	420	285	1905	772	41	813	1092
	24	1200	618	289	2107	977	64	1041	1066
Condition Averages									
Prechamber		1200	921	294	2415	1185	74	1259	1156
Chamber		1200	608	289	2097	1101	57	1158	939
Postchamber		1200	586	289	2075	904	47	951	1124
Overall Average									
		1200	705	291	2196	1063	59	1122	1074

TABLE XIV

SODIUM BALANCE

Condition	*Subject No.*	*Intake g/24 hr*	*Excretion g/24 hr*			*Balance g/24 hr*
			Feces	*Urine*	*Total*	
Prechamber	21	4.48	0.29	4.70	4.99	−0.51
	22	4.48	0.02	4.32	4.34	0.14
	23	4.48	0.01	4.30	4.31	0.17
	24	4.48	0.05	5.07	5.12	−0.64
Chamber	21	4.48	0.04	4.17	4.21	0.27
	22	4.48	0.02	3.83	3.85	0.63
	23	4.48	0.01	4.58	4.59	−0.11
	24	4.48	0.13	4.29	4.42	0.06
Postchamber	21	4.48	0.03	4.33	4.36	0.12
	22	4.48	0.02	4.15	4.17	0.31
	23	4.48	0.01	4.23	4.24	0.24
	24	4.48	0.09	4.25	4.34	0.14
Condition Averages						
Prechamber		4.48	0.09	4.60	4.69	−0.21
Chamber		4.48	0.05	4.22	4.27	0.21
Postchamber		4.48	0.04	4.24	4.28	0.20
Overall Average						
		4.48	0.06	4.35	4.41	0.07

TABLE XV

POTASSIUM BALANCE

Condition	Subject No.	Intake g/24 hr	Excretion g/24 hr			Balance g/24 hr
			Feces	Urine	Total	
Prechamber	21	3.47	0.71	3.10	3.81	−0.34
	22	3.47	0.30	2.32	2.62	0.85
	23	3.47	0.31	3.00	3.31	0.16
	24	3.47	0.31	3.07	3.38	0.09
Chamber	21	3.47	0.40	2.51	2.91	0.56
	22	3.47	0.27	2.30	2.57	0.90
	23	3.47	0.30	2.62	2.92	0.55
	24	3.47	0.45	2.67	3.12	0.35
Postchamber	21	3.47	0.43	2.58	3.01	0.46
	22	3.47	0.26	2.52	2.78	0.69
	23	3.47	0.34	2.37	2.71	0.76
	24	3.47	0.35	2.62	2.97	0.50
Condition Averages						
Prechamber		3.47	0.41	2.87	3.28	0.19
Chamber		3.47	0.36	2.53	2.89	0.58
Postchamber		3.47	0.35	2.52	2.87	0.60
Overall Average						
		3.47	0.37	2.64	3.01	0.46

TABLE XVI

CHLORIDE BALANCE
As Sodium Chloride

Condition	*Subject No.*	*Intake g/24 hr*	*Excretion g/24 hrs Urine*	*Balance g/24 hr*
Prechamber	21	10.9	11.8	–0.9
	22	10.9	11.5	–0.6
	23	10.9	11.1	–0.2
	24	10.9	13.0	–2.1
Chamber	21	10.9	11.3	–0.4
	22	10.9	9.9	1.0
	23	10.9	11.6	–0.7
	24	10.9	10.8	0.1
Postchamber	21	10.9	10.0	0.9
	22	10.9	10.3	0.6
	23	10.9	10.0	0.9
	24	10.9	11.1	–0.2
Condition Averages				
Prechamber		10.9	11.9	–1.0
Chamber		10.9	10.9	0.0
Postchamber		10.9	10.4	0.5
Overall Average				
		10.9	11.1	–0.2

TABLE XVII

HEMATOLOGY

Condition	*Subject No.*	*Hemoglobin g %*	*Hematocrit %*	*White Blood Count per mm³*	*Total Eosinophils per mm³*	*Platelets X 10⁵ per mm³*	*Reticulocytes %*
Prechamber	21	17.7	49	8,850	140	2.65	1.3
	22	15.3	40	7,400	127	2.38	1.8
	23	16.5	46	8,500	228	2.55	1.6
	24	16.9	47	5,950	91	2.63	1.0
Chamber	21	17.4	45	7,800	138	2.74	1.4
	22	14.0	38	6,700	171	2.74	1.4
	23	16.4	46	7,600	190	2.74	1.5
	24	16.4	45	5,500	98	2.74	1.3
Postchamber	21	17.7	48	8,200	129	2.65	1.4
	22	14.5	40	7,300	162	2.65	1.3
	23	16.5	47	8,400	154	2.70	1.7
	24	16.7	46	6,750	91	2.63	1.1
Condition Averages							
Prechamber		16.6	46	7,700	147	2.55	1.4
Chamber		16.1	44	6,900	149	2.74	1.4
Postchamber		16.4	45	7,650	134	2.66	1.4
Overall Average							
		16.4	45	7,400	143	2.65	1.4

TABLE XVIII

BLOOD MINERAL ANALYSES

Condition	*Subject No.*	*Calcium mg/100 ml*	*Phosphorus mg/100 ml*	*Sodium meq/l*	*Potassium meq/l*	*Chloride meq/l*
Prechamber	21	10.1	3.6	143	4.1	101
	22	10.2	3.7	139	4.1	102
	23	9.6	3.7	141	4.4	102
	24	10.2	3.8	140	4.6	104
Chamber	21	10.1	3.7	142	4.5	103
	22	10.3	3.6	143	4.7	102
	23	9.7	3.6	141	4.3	103
	24	10.1	3.4	142	4.5	102
Postchamber	21	10.9	3.7	140	4.5	107
	22	10.8	3.5	141	4.9	103
	23	10.7	3.7	139	4.6	102
	24	10.8	3.5	142	4.6	101
Condition Averages						
Prechamber		10.0	3.7	141	4.3	102
Chamber		10.1	3.6	142	4.5	103
Postchamber		10.8	3.6	141	4.7	103
Overall Average						
		10.3	3.7	141	4.5	103

TABLE XIX

BLOOD ANALYSES

Condition	*Subject No.*	*Glucose mg/100 ml*	*Creatinine mg/100 ml*	*Protein g/100*	*Albumin g/100*	*Albumin/ Globulin*
Prechamber	21	83	1.8	7.3	5.3	2.6
	22	85	1.8	8.0	5.2	2.0
	23	80	1.8	7.1	4.9	2.2
	24	81	1.6	7.4	5.4	2.9
Chamber	21	79	1.7	7.4	5.1	2.1
	22	79	1.6	7.4	4.8	1.8
	23	78	1.8	7.3	5.0	2.2
	24	78	1.9	7.3	5.0	2.2
Postchamber	21	75	2.1	7.3	5.1	2.4
	22	82	2.3	7.4	4.8	1.8
	23	83	1.8	7.4	4.7	1.8
	24	80	1.7	7.4	4.9	1.9
Condition Averages						
Prechamber		82	1.8	7.5	5.2	2.4
Chamber		79	1.8	7.4	5.0	2.1
Postchamber		80	2.0	7.4	4.9	2.0
Overall Average						
		80	1.8	7.4	5.0	2.2

TABLE XX

BLOOD ENZYME ANALYSES

Condition	*Subject No.*	*Acid Phosphatase IU**	*Alkaline Phosphatase IU**	*Serum Glutamic Oxalacetic Transaminase*	*Serum Glutamic Pyruvic Transaminase*
Prechamber	21	12.8	41.7	14.5	6.3
	22	11.9	40.0	—	—
	23	14.4	32.9	18.1	12.3
	24	14.0	26.4	14.7	5.8
Chamber	21	10.5	41.4	11.0	4.6
	22	9.3	31.0	18.9	16.2
	23	11.9	36.9	14.6	6.3
	24	11.6	29.5	13.6	7.3
Postchamber	21	8.7	42.6	9.9	3.7
	22	6.8	29.8	12.1	9.7
	23	9.7	37.2	14.7	10.6
	24	10.1	29.1	16.0	9.6
Condition Averages					
Prechamber		13.3	35.3	15.8	8.1
Chamber		10.8	34.7	14.5	8.6
Postchamber		8.8	34.7	13.2	8.4
Overall Average					
		11.0	34.9	14.5	8.8

*International Unit — Micromoles of substrate converted per minute per liter of serum.

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