

# The Use of FORMULA DIETS

## Administered via Polyethylene Tube or Orally for CONSTANT INTAKE (BALANCE) STUDIES

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**I**N RECENT YEARS the value of the balance type of study in clinical investigation has become increasingly apparent. Unfortunately, because of the difficulties inherent in preparation of constant diets, the use of this investigative tool has been confined to relatively few institutions. Further, even under the best conditions the use of rotating diets as described by Reifenstein *et al.*<sup>1</sup> makes for less than absolute constancy of intake, and hence requires very prolonged studies if dependence is to be placed upon the results which are obtained.

In this laboratory during the past year, increasing use has been made of formula diets, the material in most instances being administered at hourly intervals through a polyethylene tube (inside diameter 0.047 mm.), the tip of which lies in the stomach or in the duodenum (the latter in the case of diets containing very large amounts of fat).<sup>2</sup> Initially, this dietary program was used to permit the administration of a very high fat intake. In the course of this work, it became apparent that formula feeding had much to recommend it in terms of simplicity, and particularly in terms

of absolute constancy of food intake. In the pages which follow, prototypes of a number of formula diets will be described from the standpoint of composition and preparation.

### COMPOSITION AND PREPARATION

#### *Formulae for Tube Feeding*

#### Diet 1 (Table I)

#### *Method of Preparation*

In the preparation of this and subsequent diets, all constituents are weighed accurately on a torsion balance. The potassium chloride solution (previously prepared as a 20 per cent solution) is measured by pipette. The water is measured in a graduated cylinder. After initial washing, all utensils are thoroughly rinsed with distilled water. A portion of water is heated to dissolve the sucrose. The protein hydrolysate is added to 400 cc. of water and the mixture is made homogenous by using a blender. The powdered whole milk is blended in a similar fashion, reblending after thorough removal of the residue which adheres to the side of the bowl. The blends are then mixed manually with the potassium chloride in a suitable container, using the remaining portion of water to rinse the containers. The material is chilled in ice water and refrigerated. One hundred cc. of this mixture is administered through the tube every hour, using a chemically clean "luer-lok" syringe with a No. 18 needle. All formulae must be stirred well each time before measuring and administering.

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TABLE I

Diet 1—Milk, Protein Hydrolysate,\* Sugar Formula†

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Powdered whole milk	100 Gm.	25.8 Gm.	26.7 Gm.	38.0 Gm.	1296 mgm.	390 mgm.
Protein hydrolysate*	100 Gm.	75	—	—	200	1800
Sucrose	230 Gm.	—	—	230	—	—
Potassium chloride	2 Gm.	—	—	—	1044	—
Distilled water	2150 cc.	—	—	—	—	—
Total volume:	2400 cc.	100.8	26.7	268	2540	2190
Total calories:	1719	—	—	—	—	—

\* Protolysate®.

† Composition obtained from Chatfield and Adams,® in instances where analyses not carried out in this laboratory.

TABLE II

Diet 2—Casec®, Oil Formula

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Casec®	75 Gm.	66 Gm.	1.5 Gm.	—	30 mgm.	45 mgm.
Salad oil	206 cc.	—	186	—	—	—
Distilled water	2150 cc.	—	—	—	—	—
Tween 80®*	6 cc.	—	—	—	—	—
(See below for salt supplement)						
Total volume	2400 cc.	66	187.5	0	30 mgm.	45 mgm.
Total calories	1952	—	—	—	—	—

\* Polyoxyethylene® sorbitan monoöleate, manufactured by Atlas Powder Co.

TABLE III

Diet 3—Casec®, Oil Formula

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Casec®	170 Gm.	149.6 Gm.	3.4 Gm.	—	68 mgm.	102 mgm.
Salad oil	206 cc.	—	186	—	—	—
Distilled water	2080 cc.	—	—	—	—	—
Tween 80®	6 cc.	—	—	—	—	—
Calories	2310	150	190	0	68	102

Diet 2 (Table II)

Method of Preparation

The "Tween 80®" is added to 600 cc. of water and the mixture homogenized in a blender. This homogenate is divided into three equal portions. To each portion is added one-third of the Casec® and enough water to bring to "half level" in blender. During blending, one-third of the oil is added. This is repeated for the remaining portions, and all are combined, using the balance of water for rinsing. The entire mixture is refrigerated.

TABLE IV

Diet 4—All Fat Formula

Food	Quantity	Protein	Fat	COH
Salad oil	240 cc.	—	216 Gm.	—
Distilled water	2160 cc.	—	—	—
Tween 80®	10 cc.	—	—	—
Calories	1944	—	—	—

Diets 3 and 4 (Tables III and IV)

Method of Preparation

Identical with that for Diet 2.



TABLE V

Diet 5—Casec,<sup>®</sup> Oil (Cocoa Flavored)

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Casec <sup>®</sup>	45 Gm.	39.6 Gm.	0.9 Gm.	—	18 mgm.	27 mgm.
Salad oil	202 cc.		182			
Cocoa paste	210 Gm.	3.7	7.5	13	1566	1.6
Sucaryl <sup>®</sup> tablets	10				0.8	49
Vanilla	60 cc.				0	1.8
Distilled water	1000 cc.					
Tween 80 <sup>®</sup>	4 cc.					
Total calories	1934	43.3	190.4	13	1584.8	79.4

## Preparation of Cocoa Paste

	Quantity	Protein	Fat	Carbo- hydrate
Cocoa	100 Gm.	9 Gm.	18 Gm.	31 Gm.
Distilled water	400 cc.			
Cook in double boiler three hours.				

*Formulae for Oral Feeding*

Diets 5 and 6 (Tables V and VI)

*Method of Preparation*

To weighed cocoa paste add crushed Sucaryl<sup>®</sup> tablets and vanilla. Proceed as for fat-

Casec<sup>®</sup> formula (Table II), adding cocoa paste mixture. Save water for final rinsing. Refrigerate.

## Diet 7 (Table VII)

*Method of Preparation*

Dissolve coffee and Sucaryl<sup>®</sup> tablets in a portion of hot water. Thereafter the preparation is as for Diet 6.

## Diet 8 (Table VIII)

*Method of Preparation*

As for other oral feedings, using Kaolin instead of Casec.<sup>®</sup>

TABLE VI

Diet 6—Casec,<sup>®</sup> Oil (Cocoa Flavored)

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Casec <sup>®</sup>	114 Gm.	100.3 Gm.	2	—	45.6 mgm.	68.4 mgm.
Salad oil	170 cc.		153			
Cocoa Paste	210 Gm.	3.7	7.5	13	1566	1.6
Sucaryl <sup>®</sup> tablets	10				0.8	49
Vanilla	60 cc.				0	1.8
Distilled water	1000 cc.					
Tween 80 <sup>®</sup>	4 cc.					
Calories	1935	104	162.5	13	1612.4	120.8

TABLE VII

Diet 7—Casec,<sup>®</sup> Oil (Coffee Flavored)

Food	Quantity	Protein	Fat	COH	Potassium	Sodium
Casec <sup>®</sup>	114 Gm.	100.3 Gm.	2 Gm.		45.6 mgm.	68.4 mgm.
Salad oil	190 cc.		171			
Sucaryl <sup>®</sup> tablets	8				.6	39
Powdered coffee (Borden's)	20 Gm.				1169	100
Tween 80 <sup>®</sup>	6 cc.					
Distilled water	1000 cc.					
Calories	1958	100.3	173	0	1215.2	207.4

TABLE VIII

Diet 8—Oil, Kaolin (Cocoa Flavored)

Food	Quantity	Protein	Fat	eOH	Potassium	Sodium
Oil	222 cc.		200 Gm.			
Kaolin*	75 Gm.					
Cocoa Paste	210 Gm.	3.7	7.5	13	1566 mgm.	1.6 mgm.
Sucaryl® tablets	10				0.8	49
Vanilla	60 cc.				0	1.8
Tween 80®	4 cc.					
Distilled water	800 cc.					
Calories	1940	3.7	207.5	13	1566.8	52.4

\* Kaolin, an inert substance, acts as a stabilizer and gives body to the oral formula in the absence of Casec.®

Vitamin tablets containing a minimum of the following ingredients were given daily to all patients on tube or oral formulae:

Vitamin A—7500 u.	Vitamin E—3 mg.
Vitamin C—150 mg.	Iron—22.5 mg.
Vitamin D—1200 u.	Manganese—9 mg.
Thiamine—7.5 mg.	Iodine—0.15 mg.
Riboflavin—6 mg.	Copper—1.5 mg.
Niacinamide—45 mg.	Calcium—300 mg.
Pyridoxine—1.5 mg.	Phosphorus—225 mg.
Calcium Pantothenate 7.5 mg.	

To the Casec®-oil feedings and the all-fat feedings, mineral supplements were added as follows:

1. Calcium lactate—1 Gm. three times a day to "all fat" feeding.
2. Standard salt solution No. 1—composition: 3 Gm. potassium phosphate, 3 Gm. potassium chloride, 1 Gm. sodium sulfate per 50 cc. Dosage—50 cc. per day.
- 3 Salt solution No. 2—composition: 1 Gm. magnesium sulfate per 10 cc. Dosage—10 cc. per day.

In addition to the formula, patients may receive distilled water on the basis of individual requirement.

The intervals at which the oral diets are administered will depend upon the specific metabolic program. In our hands, these diets have usually been administered throughout the period 8:00 a.m. to 8:00 p.m.

#### DISCUSSION

The foregoing formulae are prototypes of an infinite variety of diets which may be

used, the specific composition depending upon the relative amount of protein, fat, and carbohydrate which one wishes to administer, and upon the total number of calories which are indicated.

During the past eighteen months, twenty-eight patients have been maintained on the formula tube diets for periods ranging from several weeks to four months.

In the case of the orally administered diets, only one balance study has been carried out, the other formulae being administered to patients under semi-controlled study where constant dietary intake was required for both clinical and investigative purposes. Thirty-two such patients have been maintained on oral formula diets for periods ranging from several weeks to three and one-half months. We have been agreeably surprised to receive far fewer complaints than had been anticipated.

In the case of the "all fat" dietary intake it is obvious that prolonged administration of this type of diet through other than a tube approach would be impossible in most if not all instances. One patient was maintained on such a diet for a period of one month, clinical ketosis being prevented by the concomitant administration of corticotropin and cortisone.<sup>4</sup>

In Figure 1 are shown some of the data obtained in a typical balance study using this type of dietary intake. Because of the constancy of the intake, one may attach significance to somewhat smaller changes than would be possible with the usual rotating balance diet.

To obtain maximal constancy and to reduce

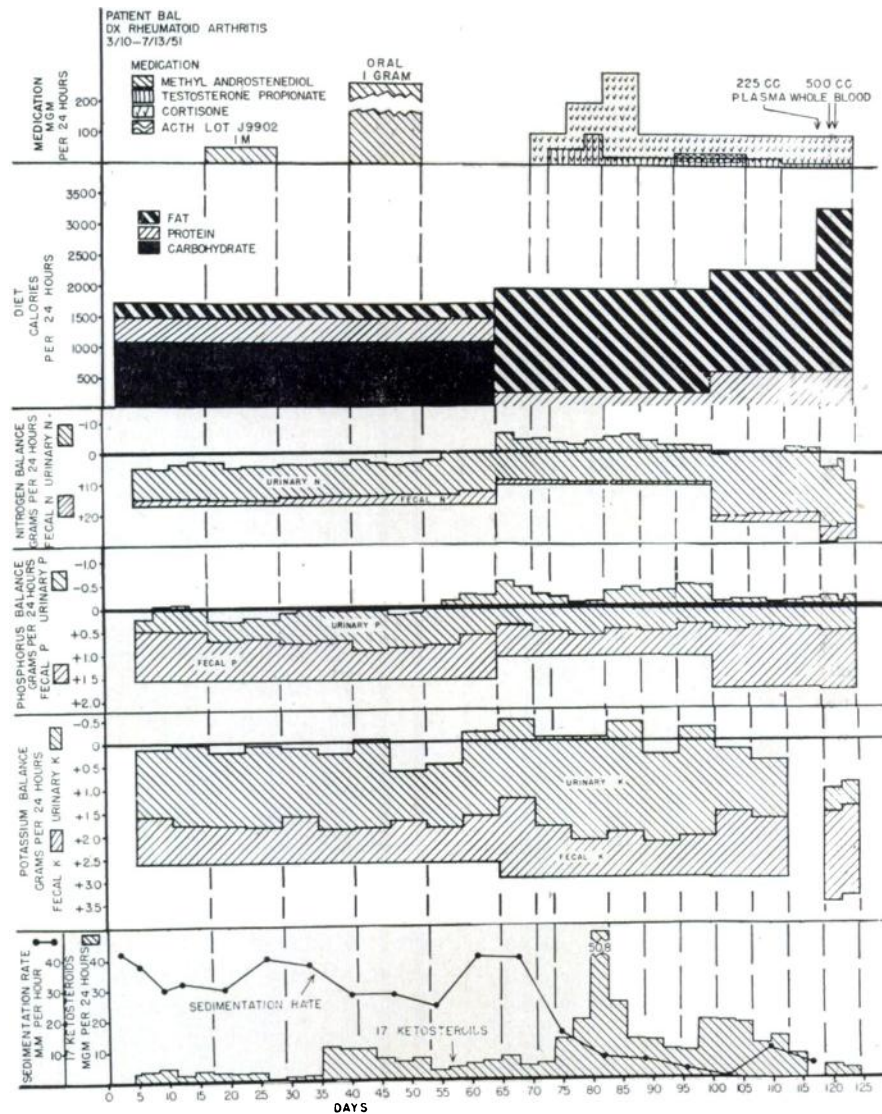


Figure 1—Long-term metabolic study in which formula intake was used throughout.

the number of quantitative determinations of dietary constituents to a minimum, large supplies of each material of identical lot numbers are kept on hand.

#### SUMMARY

Over a period of eighteen months, sixty patients have been maintained on constant formula intake for periods ranging from one to four months. The use of this type of diet has the advantages of extreme constancy of intake and relative simplicity of preparation. The use of this procedure makes balance

studies feasible in institutions where metabolic ward facilities are not available.

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## REFERENCES

1. REIFENSTEIN, E. C., ALBRIGHT, F., and WELLS, S. L.: The accumulation, interpretation, and presentation of data pertaining to metabolic balances, notably those of calcium, phosphorus, and nitrogen. *J. Clin. Endocrinol.* 5: 367, 1945.
2. KINSELL, L. W., OLSON, F., BOLING, L., PARTRIDGE, J., and MARGEN, S.: Modification of the clinical and metabolic effects of ACTH by dietary means (Letter to the Editor). *J. Clin. Endocrinol.* 11: 1030, 1951.
3. CHATFIELD, C., and ADAMS, G.: Proximate composition of American food materials. *U. S. Dept. of Agriculture, Circular* No. 549 (June), 1940.
4. KINSELL, L. W., MARGEN, S., BOLING, L., and MICHAELS, G. D.: Studies in fat metabolism: The effect of ACTH and of steroid hormones upon the ketosis induced by the feeding of a pure fat diet to human subjects, *Proc. of the*

Assoc. for the Study of Internal Secretions. *J. Clin. Endocrinol.* 11: 773, 1951.

## RESUMEN

*El uso de las dietas administradas a través de un tubo de politeno o por vía oral para los estudios de ingestión constante (equilibrio)*

Durante 18 meses, por períodos de 1 a 4 meses, 60 pacientes han sido mantenidos mediante la ingestión de una fórmula constante. El empleo de este tipo de dieta ofrece las ventajas de una constancia extrema de ingestión, y de la sencillez relativa del método de preparación. El empleo de este procedimiento rinde hacederos los estudios de equilibrio en institutos donde faltan los servicios de una sala especial para enfermos de metabolismo.

