FAT METABOLISM OF INFANTS AND YOUNG CHILDREN

II. FAT IN THE STOOLS OF INFANTS FED ON MODIFICATIONS OF COW'S MILK *

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In a previous article of a series of studies on the fat metabolism of infants and young children we have reported the results of the examination of stools of breast fed infants. In the present paper are presented the results of the study of a large number of stools of infants fed on cow's milk or various modifications of the same, with or without carbohydrate additions. The digestion of the larger number of the infants was quite normal; some were suffering from disturbances of digestion of varying degrees of severity.

The questions here considered are practically the same as those discussed in the study of the stools of breast fed infants, namely:

1. What is the variation in the per cent. of total fat and the distribution of fat in the stools of infants fed on cow's milk, under different conditions of digestion?

2. How is the fat per cent. and the distribution of fat in the stool affected by the fat intake?

3. What per cent. of fat is retained under different conditions of digestion and how is the retention affected by the amount of fat intake?

The material examined consisted of 128 specimens of feces from seventy-seven infants whose ages ranged from 2 to 18 months. Some of the older infants who were taking whole milk are included because the amount of solid food they were receiving in addition was not sufficient to put them in the class with other children of their age on mixed diet. The exact food in each case is given in the tables. The milk formulas are expressed as per cent. of fat, carbohydrate and protein in the order stated. All additions to the milk — sugars, flours, etc., have been included in the values as stated. Other additions to the diet — cereals, orange juice, olive or cod liver oil, etc. — are stated as such. The condition of the children with respect to digestion is considered in connection with the various tables.

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The collected stools were dried on the waterbath to constant weight and ground to a powder. Analyses were made for total fat and its distribution as soap, free fatty acids and neutral fat. The findings numbered from 49 through 101 were obtained by the use of the method recently described by us,[1] and which was used to obtain the results in our previous paper on "Fat in the Stools of Breast Fed Infants."[2] The findings in the remaining cases, numbered from 102 through 176, were obtained by a modified Soxhlet extraction.[3] The separation of free fatty acids and neutral fat has not been included in this paper unless obtained by the titration method.

Since the soap content of the acid stools of breast fed infants is increased during the drying process, an investigation was made to determine whether a similar change occurs in the stools of children fed on cow's milk. Accordingly, a large composite specimen, representing normal or practically normal types of stools of artificially fed infants, was analyzed both in the moist state and after drying on the waterbath. It was found by this investigation that neither the total fat nor the distribution of fat was affected by drying. It is possible that acid diarrheal stools, like the acid stools of breast fed infants, might show a lower soap if analyzed moist than is present after drying.

The gross appearance of the stools is commonly used by pediatrists as their chief guide in infant feeding. Hence, the data presented have been classified according to the gross appearance of the stools and their water content.

Tables 1 to 9 are concerned with the fat per cent. of dried weight and the distribution of fat as soap, free fatty acids and neutral fat; Tables 10 to 18 consider the fat retention.

THE AMOUNT AND DISTRIBUTION OF THE FAT

Table 1 includes the findings on those stools which were hard, or dry and crumbly; that is, all the stools which might be regarded as constipated. Most of the infants could be classed as normal, healthy children; the rest, though under weight, were doing well at the time.

The fat per cent. of dried weight is quite uniform, averaging 36.0. There are only three values below 30, and only five above 40 per cent. The soap per cent. of total fat is very high, averaging 73.8. In thirteen instances the soap is over 70 per cent. of the fat in the stool. Of the other two constituents the fatty acids, averaging 17.6 per cent., exceed the neutral fat, which averages 9.0. In only two cases is this relationship reversed.

1. Am. J. Dis. Child. **17**:38 (Jan.) 1919.
2. Am. J. Dis. Child. **17**:241 (Apr.) 1919.
3. Am. J. Dis. Child. **3**:1, (Jan.) 1912.

TABLE 1.—TOTAL FAT AND FAT DISTRIBUTION IN CONSTIPATED STOOLS

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
						Soap	Free Fatty Acids	Neutral Fat
77	F. J.	15	Whole milk Fat Carb. Prot.	30.0	35.1	89.2	7.9	2.9
67	M. R.	6	2.4 8.3 2.5	23.4	37.3	80.7	9.8	9.5
60	F. N. 1	11	2.6 11.7 2.9 1 oz. orange juice	26.2	44.5	80.4	10.0	9.6
71	P. D. 2	7	2.4 8.2 3.0	22.6	38.6	79.0	17.9	3.1
49	G. H.	7.5	4.1 4.9 2.2 (top milk) 2 tsp. malt. & C. L. O.	48.3	48.1	78.0	9.5	12.5
171	R. M. 3	9	2.5 6.8 2.5	31.5	31.4	77.4		
138	E. R. 1	4	1.4 5.0 1.2	13.2	25.9	77.2		
70	P. D. 1	7	2.4 8.2 3.0	22.9	36.3	76.4	18.7	4.9
128	A. R. 5	8	2.4 6.6 2.8	21.6	30.8	74.8	7.3	17.9
89	M. O. 2	5.5	1.5 5.0 2.7 (evaporated milk)	11.7	36.7	74.5	17.9	7.6
93	A. T.	3.5	1.5 5.0 2.7 (evaporated milk)	9.5	15.7	74.1	18.6	7.3
72	A. K.	5.5	2.8 5.0 2.6	22.1	46.1	72.9	18.0	9.1
75	M. H.	8	3.0 5.0 2.8 1 tbsp. cereal	20.9	41.5	71.7	18.8	9.5
65	P. D. 3	7.5	2.3 9.2 2.8	24.0	34.2	69.5	27.0	3.5
52	J. S.	15	Whole milk, C.L.O.* 2 tbsp. cereal	30.5*	39.5	69.1	19.9	11.0
99	M. B. 2	13	Whole milk	17.0	34.3	68.1	21.4	10.5
61	E. C. 1	14	2.3 7.3 2.4 2 tbsp. cereal, 1 prunes, 1 spinach	25.5	21.8	65.3	21.2	13.5
90	W. D.	2.5	1.6 5.2 1.4 (dried milk)	11.3	50.9	63.5	24.2	12.3
69	M. L.	7	3.0 7.0 2.8 2 tbsp. cereal	23.0	34.5	59.9	31.2	8.9
Average				22.9	36.0	73.8	17.6	9.0

* Intake uncertain; cod liver oil indefinite.

Table 2 presents the results of analyses of the stools of the type generally considered normal. They were formed or semiformed, smooth and homogeneous. They were not hard or dry and showed no signs of mucus. All the infants were in good condition as to digestion and were gaining weight.

The fat per cent. of dried weight in this group averages the same as that in Table 1, and the range is practically identical. The fat per cent. in the stool of E. M., 82.6 per cent., is the highest value that has ever come under our observation. This child was brought to the hospital suffering from forcible vomiting. She was taking 6 ounces of cream (the top 3 ounces from each of 2 quart bottles of milk) with 18 ounces of water and dextrimaltose. This formula was thus high in fat and carbohydrate and low in protein and salts. The child was also receiving two tablespoonfuls of milk of magnesia daily. After the collection of the stools for analysis, the food was changed and the vomiting ceased. In spite of the extremely high per cent. of fat in the stool of this child, the stool was normal in appearance, and it contained a high per cent. of soap. The large amount of magnesia taken may possibly have influenced the soap formation.

TABLE 2.—TOTAL FAT AND FAT DISTRIBUTION IN STOOLS OF NORMAL CONSISTENCY

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
62	J. M.	7	2.2 6.7 2.0	24.4	20.6	89.3	6.1	4.6
81	R. B.	15	Whole milk, 4 tbsp. cereal	31.1	56.7	89.0	5.1	5.9
58	J. I.	12	2.4 8.7 2.6 3 oz. orange juice	28.6	22.4	85.8	6.2	8.0
87	B. I.	3.5	1.2 5.3 1.5	14.6	21.3	85.7	8.5	5.8
172	F. P. 1	3	1.4 6.7 1.4	14.7	45.4	85.2		
84	N. K. 3	2	2.4 4.8 2.1	15.1	15.7	81.0	10.9	8.1
73	P. S. 1	8	2.1 6.6 2.0	22.0	25.7	80.8	9.7	9.5
91	M. O. 1	5.5	1.5 5.0 2.7 (evaporated milk)	11.5	39.0	80.0	12.1	7.9
53	B. B.	3	3.0 7.0 1.8 (top milk)	27.8	50.2	79.2	14.6	6.2
76	P. S. 2	8	2.4 6.5 2.3 1 oz. orange juice	18.8	19.7	79.0	10.5	10.5
158	H. B.	13	Whole milk, 2 pc. bread, 2 tbsp. cereal	34.7	36.0	79.0	15.0	6 0
124	W. J. 1	5	2.2 2.9 1.7	23.3	38.7	78.9		
68	M. M.	11	2.1 8.0 2.5 2 oz. potato, 1 tsp. butter	23.3	21.4	77.6	9.9	12.5
55	J. D.	7	2.7 8.8 2.7	30.1	30.6	72.9	15.6	11.5
54	R. C.	8.5	2.5 6.0 2.4 4 tbsp. cereal, 1 veg. 1 oz. orange juice	32.8	28.2	72.8	18.2	9.0
57	M. S. 2	8	2.7 6.0 2.8 1 tbsp. cereal, 1 tsp. veg., 1 oz. beef juice, 2 oz. orange	29.4	34.7	72.2	18.6	9.2
168	W. J. 10	7	0.7 2.3 2.2	7.9	18.9	72.2		
96	R. L. 1	12	Whole milk	30.0	32.6	72.2	13.3	14.5
78	M. S. 1	4	1.7 5.0 1.8	16.7	42.9	72.0	23.0	5.0
140	R. M. 2	4.5	1.8 5.0 2.1	18.9	39.0	71.8		
50	B. P.	10 •	4.1 4.9 2.0 (top milk)	36.5	36.4	71.2	18.9	9.9
110	D. L.	8	2.2 7.3 2.0	24.1	36.0	70.1		
88	G. B.	3	1.5 6.5 3.0 (evaporated milk)	12.7	33.3	68.5	19.6	11.9
105	R. S. 1	7	1.8 6.2 2.1 12 c.c. olive oil	33.8	34.1	63.5		
80	R. L. 3	12	Whole milk, 1 pc. bread, 1 tbsp. cereal	30.5	51.0	62.6	27.8	9.6
51	E. M. 1	2	5.0 5.0 0.9 (top milk)	36.0*	82.6	61.2	31.3	7.5
163	J. D.	5	1.8 5.0 2.1	18.9	46.5	59.1		
100	M. B. 1	13	Whole milk	17.0	38.1	56.4	24.7	18.9
122	V. D.	9	1.6 5.4 1.6 6 gm. olive oil	22.3	38.9	52.2		
79	R. L. 2	12.5	Whole milk, 1 pc. bread, 1 tbsp. cereal	30.5	48.6	43.7	42.7	13.6
117	W. H. 2	12	1.8 5.6 1.6 12 c.c. C. L. O.	25.4	37.3			
Average				24.0	36.2	72.8	16.5	9.4

* Intake approximate; no sample of top milk available for examination.

The distribution of fat shown in Table 2 is also almost identical with that in Table 1. The soap averages 72.8 per cent of the total fat. There are three values lower than any found in Table 1, but Table 2 contains a proportionally larger number of high values. The averages for free fatty acids and neutral fat are practically the same in the two groups. Hence, as to total fat and distribution of fat, no distinction can be made between the stools of normal appearance and the hard, constipated type. The chief difference appears to be a

matter of water content. This view is confirmed by a comparison of the protein and ash content of the two types of stools. The average protein per cent. of dried weight of eight constipated stools was found to be 26.5, the average of eight normal stools 25.4. The average ash per cent. of dried weight of fifteen hard stools was 23.7, that of twenty normal stools was 24.1 per cent. of the dried weight. These averages were based on analyses made on the material considered in Tables 1 and 2. The most striking point brought out in Table 2 is that so many normal stools of healthy infants contain so high a proportion of their fat in the form of soap.

In Table 2 are presented the findings on a group of stools which were similar in appearance to the normal, but softer, for the most part not formed, but smooth and homogeneous and showing little or no mucus. None were included in this group that contained more than 75 gm. of water in the twenty-four hours' stool and none in which the dried weight was less than 14 per cent. of the moist weight. All but three of the infants were in good condition and gaining weight, although several of them had previously suffered from digestive disturbances.

TABLE 3.—FAT CONTENT AND DISTRIBUTION IN STOOLS SOFTER THAN NORMAL

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
86	J. M.	4	1.6 5.2 1.4 (dried milk)	13.4	34.5	80.4	11.0	8.6
83	A. P.	6	1.8 5.0 2.2	15.1	18.7	75.9	14.3	9.8
63	F. N. 2	11	2.4 11.6 2.7	24.1	41.1	72.4	19.6	8.0
97	B. W. 1	15	1 oz. orange juice Whole milk, half egg, 1 pc. zwieback	27.6	39.2	72.1	16.2	11.7
56	J. K. 1*	15	4.2 7.7 2.7 (top milk)	29.7	29.6	71.3	17.3	11.4
101	J. K. 2	16	Whole milk, 1 oz. beef juice, 1 tbsp. cereal, 1 fruit	16.5	12.8	68.7	19.6	11.7
94	E. W.	5	0.5 10.0 2.1 (malted milk)	3.4	16.4	68.2	16.7	15.1
74	E. C. 2	15	1.8 3.9 2.0 2 tbsp. cereal, 1 prunes	21.1	26.2	64.9	30.3	4.8
153	R. S. 3	8	2.4 8.2 2.3	27.7	25.6	62.9		
173	I. P. 1	4	1.1 10.5 1.6 8 gm. olive oil	20.2	39.0	58.1		
114	R. S. 2	8	2.4 8.2 2.3	27.7	29.0	57.9		
137	R. D. 1†	7.5	1.9 6.5 1.7	19.7	45.0	54.8		
103	W. J. 6	6	2.7 2.7 2.4	31.5	46.3	49.3		
145	R. M. 1	3.5	1.6 5.0 1.4	18.5	53.2	38.3		
66	P. S. 3	10	2.5 10.6 2.6 15 c.c. orange juice	23.7	10.2	35.9	34.4	29.7
64	L. R.‡	12	1.7 5.9 2.4 12 c.c. cod liver oil	24.6	43.8	26.3	65.8	7.9
	Average			21.5	31.9	59.8	24.5	11.9

* Marked case of malnutrition.
† Gaining, but had a nasal infection with K. L. bacillus; subsequently very ill.
‡ Very delicate; rickets and marasmus.

Table 3 shows some marked variations from 1 and 2. The total fat per cent. of dried weight is lower; the average being 31.8 per cent., and the range 10.2 to 46.3. The fat distribution shows an average for soap of 59.8 per cent., which is considerably lower than in the normal and the constipated stools; consequently, the fatty acids and neutral fat are higher, although they bear the same relation to each other as in the previous tables. The soap, however, still represents considerably more than half the fat of the stool.

Table 4 includes the findings on a number of stools which were not normal in appearance, but were not sufficiently loose to be classed as diarrheal. None were smooth and homogeneous, and all showed fat curds or mucus, or both, in considerable amount. The digestion of the children whose stools are considered in this table was not quite normal, and a large proportion of the infants subsequently developed diarrhea.

TABLE 4.—FAT CONTENT AND DISTRIBUTION IN STOOLS WHICH WERE NOT HOMOGENEOUS

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
						Soap	Free Fatty Acids	Neutral Fat
59	L. H.*	9	Fat 2.6 Carb. 6.0 Prot. 1.8					
			2.3 5.2 2.0	19.8	27.5	77.8	17.5	4.7
98	A. K.	18	Whole milk, 4 tbsp. cereal, 1 tbsp. veg., 15 c.c. orange	26.4	41.4	76.2	14.4	9.4
92	L. B.*	3.5	1.7 9.7 1.4	12.5	45.2	67.3	17.8	14.9
82	P. L.*	4	1.8 5.2 1.6 (dried milk)	15.7	26.1	64.7	27.7	7.6
85	C. M.	2	1.6 5.0 1.7	14.4	33.4	64.4	23.7	11.9
155	D. W. 1†	5	1.8 5.0 1.6	17.2	48.8	55.2	13.1	31.7
154	W. H. 1*	12	1.8 5.6 1.5	17.4	14.8	54.2		
126	W. H. 4	14	2.4 6.2 2.3 1 tbsp. cereal, 12 c.c. C. L. O.	35.8	38.6	50.5		
104	C. R.	4	0.0 6.5 1.6	0.0	11.8	44.1		
174	B. B.*	4	1.4 6.7 1.4	14.7	54.7	41.2		
170	R. B. 2*	3	1.4 1.6 1.2	13.2	33.9	30.2		
119	W. H. 5	14	2.4 6.1 2.3 1 tbsp. cereal	25.2	29.0	29.7		
160	R. C. 1‡	5	0.9 5.4 2.0	6.7	18.8	23.4		
113	J. S. 1	7.5	1.2 5.0 3.2 14 c.c. olive oil	26.6	13.1	16.8		
169	R. C. 2‡	5	1.2 5.9 1.4	9.2	50.3	16.2		
166	A. A.*	7	1.4 6.9 2.0	11.4	35.6	1.6	21.1	77.3
Average				16.1	32.7	44.6	19.3	22.5

* Child delicate; digestion not good.
† Child not in good condition; tetany; rickets; developed diarrhea.
‡ Child in bad condition; edema; idiot.

The total fat per cent. of dried weight of the stools in this group is not greatly different in average or in range from that of the previous tables. In this group the wide range may be explained by the fact

that some of the stools contained considerable mucus, which diminishes the fat per cent., while others contained fat curds, which increase the per cent. of total fat. The most notable feature of this table is the extremely wide range in per cent. of soap fat. This is not surprising since the stools were classified together only because they contained curds and mucus and were not homogeneous. The soap fat forms on the average 44.6 per cent. of the total fat.

The group of stools, the analyses of which are shown in Table 5, were distinctly loose, containing from 70 to 100 gm. of water in the daily stool, which is more than twice the amount usually contained in normal stools. The infants observed were convalescent from digestive disturbance and were in fair condition.

TABLE 5.—FAT CONTENT AND DISTRIBUTION IN LOOSE STOOLS

No.	Case	Age, Months	Feeding			Intake of Fat, Gm. Daily	Analyses of Stools			
							Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat	Carb.	Prot.			Soap	Free Fatty Acids	Neutral Fat
129	J. G. 4	8	2.8	6.5	2.5	32.3	38.1	54.0		
148	W. J. 3	6	1.6	4.7	2.1	18.3	31.7	50.2		
112	W. J. 5	7	2.3	2.6	2.3	27.0	47.8	40.8		
125	W. G. 2	7	2.1	4.9	2.6	22.5	29.1	35.1		
107	F. H. 11	13	2.4	6.8	2.5	29.9	18.1	32.6		
151	W. G. 1	7	1.7	4.8	2.4	17.9	20.2	30.8		
144	V. R. 2	3	1.6	5.0	1.4	18.7	24.0	30.4		
143	F. S.	6	1.7	6.0	2.1	18.7	36.1	28.3	16.6	55.1
108	W. G. 3	7.5	2.3	4.7	2.6	29.8	32.3	24.3		
			6 c.c. olive oil							
116	W. G. 4	7.5	1.7	4.5	2.2	25.5	41.2	17.6		
			8 c.c. olive oil							
115	F. H. 9	13	2.1	5.7	2.5	26.2	17.8	14.4		
159	D. F. 3	4	1.2	5.2	1.5	12.9	25.4	8.2		
Average						23.3	30.2	30.6	(16.6)	(55.1)

The average proportion of the dried weight which is fat as shown in this table is similar to that of the two preceding tables, but the range is narrower. With the increase in the proportion of water in the stools a marked reduction of the soap per cent. of total fat is observed. In this group it averages 30.6 per cent. and there are only two values over 50 per cent.

The diarrheal stools are arranged in two groups according to the amount of water in the daily stools. Those which contained between 100 and 200 gm. of water daily are grouped together and are designated simply as diarrheal, and the findings are given in Table 6. The stools which contained more than 200 gm. of water daily are classed as severely diarrheal and the analyses are shown in Table 7. Most of the children were very ill and the digestion of all was markedly abnormal.

TABLE 6.—Fat Content and Distribution in Diarrheal Stools

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
102	J. G. 3	7.5	2.2 9.0 2.2	25.4	27.3	47.9		
147	W. H. 3	14	2.4 6.1 2.3 1 tbsp. cereal	18.4	22.3	27.4		
146	J. G. 1	7	2.4 5.6 2.2 12 c.c. olive oil	39.7	49.9	24.6		
149	W. J. 2	5	1.7 6.3 1.7	18.1	36.2	21.1		
136	F. H. 2	10	2.7 3.8 2.2	33.6	29.5	20.3		
167	R. B. 3	3.5	1.1 3.2 1.2	9.2	34.1	20.8		
150	J. G. 2	7	2.4 5.6 2.2	30.7	33.8	18.7		
130	R. B. 1	3	1.4 5.5 1.2	13.2	16.6	16.3		
127	D. W. 2	5	1.8 5.8 1.6 6 c.c. cod liver oil	22.2	48.9	15.3	23.2	61.5
161	I. P. 2	4.5	1.4 12.0 1.8 8 c.c. olive oil	24.4	25.4	15.1		
162	D. F. 1	3.5	1.5 5.9 1.5	15.8	24.0	14.7		
165	P. V.	5.5	1.4 5.4 1.7	15.0	32.2	13.8		
139	J. D.	5	1.6 5.8 1.6 3.4 c.c. cod liver oil	17.0	48.0	13.6	24.0	62.4
134	D. F. 2	4	1.3 5.2 1.5	14.0	26.2	12.1		
135	F. H. 4	11	1.6 4.7 3.0	20.0	14.2	11.8		
142	W. J. 6	7	1.0 2.9 2.4	12.1	31.8	11.1		
175	I. G.	2.5	1.8 4.8 2.3 (evaporated milk)	14.7	61.4	7.4	36.8	55.8
118	A. H.	11	2.0 5.3 1.8	25.2	45.9	4.7		
152	M. R.	4	1.3 6.9 2.2	5.4	41.5	3.5	50.7	45.8
133	F. H. 10	13	1.6 6.7 2.5	20.6	16.4	1.6		
106	V. C. 3	5	1.8 2.8 2.1 12 c.c. cod liver oil	30.2	54.2	0.0	17.5	82.5
111	E. R. 2	10	1.8 6.3 2.2 4 tbsp. cereal, 12 c.c. cod liver oil	27.1	31.6	0.0		
123	E. R. 3	10.5	1.4 6.3 2.2 4 tbsp. cereal, 12 c.c. cod liver oil	23.4	39.4	0.0		
131	E. R. 1	10	2.0 8.7 2.7 4 tbsp. cereal	16.8	44.1	0.0		
164	B. S. 2	12	1.9 6.8 2.1 1 tbsp. cereal	15.5	29.5	0.0		
141	F. H. 3	11	0.0 6.0 3.5	0.0	3.9	0.0		
	Average			19.5	33.4	12.4	30.4	61.6

TABLE 7.—Fat Content and Distribution in Severely Diarrheal Stools

No.	Case	Age, Months	Feeding	Intake of Fat, Gm. Daily	Analyses of Stools			
					Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Fat Carb. Prot.			Soap	Free Fatty Acids	Neutral Fat
157	E. R. 2	4.5	1.3 5.9 1.2	11.8	30.2	22.8		
132	F. H. 1	10	2.6 4.5 2.4	32.4	34.7	17.0		
95	J. B.	4	1.3 3.5 1.6 (evaporated milk)	6.4	46.1	9.8	43.2	37.0
156	W. S. 1	4	1.6 5.8 1.5	17.0	36.6	8.6		
109	S. J.	9	2.7 5.3 2.5 (evaporated milk)	29.1	57.5	8.9	36.3	54.8
121	V. C. 2	5	1.8 2.9 2.1 6 c.c. cod liver oil	23.6	49.5	3.3	30.3	46.4
120	V. C. 1	5	1.8 5.6 2.0 6 c.c. cod liver oil	23.6	43.6	0.0	32.7	67.3
176	B. S. 3	13	1.8 5.9 1.9 one-half tbsp. cereal	11.6	27.0	0.0		
	Average			19.4	40.7	8.8	38.1	56.4

In Table 6 the total fat, averaging 33.4 per cent. of the dried weight, shows no significant difference from that of the two preceding groups. Table 7, however, shows a marked increase in per cent. of total fat, averaging 40.2, the highest of all the groups. The per cent. of total fat which is soap shows a striking decrease in both these groups, averaging only 12.4 in Table 6 and 8.8 in Table 7. In Table 6 there is only one soap value over 27 per cent., while in the group of severe diarrhea, Table 7, there are only two instances with a soap per cent. above 10. Although the number of cases in which a separation of the neutral fat and the free fatty acids was obtained was small, the high per cent. of neutral fat in all shows that a much lessened degree of fat splitting is one of the accompaniments of diarrhea.

For comparison, the averages of the seven previous tables have been brought together in Table 8.

TABLE 8.—SUMMARY OF AVERAGES OF TABLES 1 TO 7

Table	Type of Stools	Number of Observations	Intake of Fat, Gm. Daily	Analyses of Stools			
				Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
					Soap	Free Fatty Acids	Neutral Fat
1	Constipated.....	19	22.9	36.0	73.8	17.6	9.0
2	Normal.....	31	24.0	36.2	72.8	16.5	9.4
3	Softer than normal.	16	21.5	31.9	59.8	24.5	11.9
4	Not homogeneous...	16	16.1	32.7	44.6	19.3	22.5
5	Loose.....	12	23.3	30.2	30.6	16.6*	55.1*
6	Diarrheal.....	26	19.5	33.4	12.4	30.4	61.6
7	Severely diarrheal...	8	19.4	40.7	8.8	38.1	56.4

* Only one case.

This table gives an answer to the first question stated at the beginning of this article, namely, What is the variation under different conditions of digestion in the per cent. of total fat and the distribution of fat in the stools of artificially fed infants?

The average values for the fat per cent. of dried weight in the various groups range from 30 to 40 per cent. The constipated stools have the same average per cent. as the normal. The fat average is highest in the group of severe diarrhea. In the groups of stools intermediate between the normal and those of severe diarrhea the total fat per cent. of dried weight is lower than in the normal. This may be due to the presence in these types of stools of more or less mucus. Undoubtedly the stools in severe diarrhea also contain much mucus, but in this condition the absorption of fat is so very poor that there is an extremely large amount of fat in the stool and a consequently high per cent. of the dried weight in spite of the presence of much mucus.

The distribution of fat shows wide variation according to the type of the stool. The stools which were normal and nearly normal in appearance show very high average values for soap. It is only when the stools show in their gross appearance evidence of digestive disturbance that the average values for soap drop below 50 per cent. of the total fat. In diarrheal stools the soap forms a very small proportion of the total fat. The fatty acids form the next larger proportion of the total fat in good stools, the lower neutral fat indicating excellent splitting of the ingested fat. In the diarrheal stool the proportion of neutral fat is greatly increased, forming on the average more than half the total fat.

Table 9 shows for comparison the average analyses of the stools of nursing infants and of infants taking cow's milk modifications. It gives average analyses of the normal stools and also the averages of the analyses of all the stools not diarrheal. All the children, the analyses of whose stools are included in the second average, were in fairly good condition as to digestion, most of them in excellent condition.

TABLE 9.—COMPARISON OF ANALYSES OF STOOLS OF INFANTS TAKING COW'S MILK AND THOSE TAKING BREAST MILK

Food	Type of Stool	Fat per Cent. of Dried Weight	Per Cent. of Total Fat as		
			Soap	Free Fatty Acids	Neutral Fat
Cow's milk.....	Normal (Table 2).....	36.2	72.8	16.5	9.4
Breast milk.....	Normal (Table 1)*.....	42.1	57.8	26.3	15.9
Cow's milk.....	Average† (Tables 1 to 5).....	34.1	60.5	18.6‡	12.1‡
Breast milk.....	Average† (Tables 1 to 3)*.....	34.5	43.1	36.7	20.2

* Preceding paper. (Fat in the Stools of Breast Fed Infants.)

† Average of analyses of all types of stools except diarrheal. All the children were in fairly good condition as to digestion, most of them in excellent condition.

‡ Since the separation of free fatty acids and neutral fat was not obtained on all the stools, the average of soap, free fatty acids and neutral fat do not total to 100 per cent.

The normal stools of nursing infants show a higher average fat per cent. of dried weight, 42.1, than do the stools of infants fed on modifications of cow's milk, 36.2. But in the average which includes all the various types of stools exclusive of diarrheal, the fat per cent. of dried weight is exactly the same with both cow's milk and breast milk feeding. The soap per cent. of total fat is much higher in the stools of infants taking cow's milk than in those of infants taking breast milk, both in the case of normal stools and that of various types whose analyses were averaged together. This difference would have been even greater if the determinations had been made on the moist stools, since a lower soap value is found in the stools of nursing infants when examined moist than is found in the dried stool, while no such difference is found in the stools of infants taking cow's milk.

The neutral fat is distinctly higher in the stools of breast fed infants. The values for neutral fat need no correction for purposes of comparison, since the amount of neutral fat is not changed by the process of drying. From the foregoing facts the inference would seem to be warranted that in artificial feeding the aim should be to obtain a stool with a high proportion of soap fat rather than one in which the soap is lower, as it is in the stools of nursing infants.

The amount of daily fat intake has been incorporated in Tables 1 to 7. A study of these figures fails to reveal any definite relation between the fat intake and the per cent. of total fat or its distribution in the stool. The intake varied in the cases studied from 0 to 48.3 gm., the average intake for the various groups ranging from 16 to 24 gm. A large number of the cases with high fat intake appear in Tables 1 and 2. The per cent. of fat in the formula seems to bear no definite relation either to the per cent. of fat in the stool or its distribution.

RETENTION OF FAT

In about three fourths of the cases considered in the preceding tables, the stools were collected for a definite period, so that the actual and percentage retention of the fat intake was obtained. These values are also arranged according to the gross appearance and water content of the stool.

The first group, Table 10, includes the findings on those cases in which the stools were constipated.

TABLE 10.—RETENTION OF FAT WHEN STOOLS WERE CONSTIPATED

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
49	G. H.	48.3	2.98	45.3	93.8
171	R. M. 3	31.5	3.12	28.4	90.2
77	F. J.	30.0	1.75	28.3	94.2
60	F. N. 1	26.2	4.12	22.1	84.3
61	E. C. 1	25.5	1.71	23.8	93.3
65	P. D. 3	24.0	2.95	21.1	87.7
67	M. R.	23.4	2.79	20.6	88.0
70	P. D. 1	22.9	2.21	20.7	90.3
71	P. D. 2	22.6	3.34	19.3	85.2
72	A. K.	22.1	3.04	19.1	86.2
128	A. R. 5	21.6	2.12	19.5	90.1
	Average.....	27.1	2.74	24.4	89.9

The per cent. of the fat intake retained ranges from 84 to 94, with an average of nearly 90. The largest intake in all the cases studied was that of G. H. (No. 49). This child retained 93.8 per cent. of the unusually large intake of 48.3 gm., having an actual retention of 45.3 gm. In the case of F. N. (No. 60), who had the largest loss of fat in the stool, the food contained an unusually high proportion of carbohydrate.

Table 11 presents the figures for fat retention in the cases in which the stools were of normal consistency.

TABLE 11.—RETENTION OF FAT WHEN THE STOOLS WERE NORMAL IN APPEARANCE

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
50	B. P.	36.5	2.91	33.6	92.1
158	H. B.	34.7	4.93	29.8	85.8
105	R. S. 1	33.8	2.37	31.4	93.1
54	R. C.	32.8	2.70	30.1	91.8
81	R. B.	31.0	3.91	27.1	87.4
55	J. D.	30.1	1.35	28.8	95.6
96	R. L. 1	30.0	4.07	25.9	86.4
57	M. S. 2	29.4	3.36	26.0	88.6
58	J. I.	28.6	1.30	27.3	95.4
117	W. H. 2	25.4	2.24	23.2	91.2
62	J. M.	24.4	1.14	23.3	95.3
110	D. L.	24.1	3.41	20.7	86.0
68	M. M.	23.3	1.24	22.1	94.7
122	V. D.	22.3	2.76	19.5	87.6
73	P. S. 1	22.0	0.73	21.3	96.7
140	R. M. 2	18.9	2.59	16.3	86.2
76	P. S. 2	18.8	0.62	18.2	96.7
87	B. L.	14.6	0.38	14.2	97.4
	Average.....	26.7	2.33	24.4	91.3

The range in retention is from 85.8 to 97.4 per cent. of the fat intake, the average being 91.6. Three cases (Nos. 81, 96, 158) show a high loss of fat, comparable with that of No. 60 in the preceding table. These three infants were all fed on whole milk, two of them having cereal additions. A comparison of Tables 10 and 11 shows that there is no significant difference in the average daily loss of fat whether the stools are hard and constipated or of normal consistency. In Table 11, representing normal stools, there are seven instances in which there is a smaller daily fat loss than the lowest reported in Table 10 in which the stools considered were constipated.

TABLE 12.—RETENTION OF FAT WHEN THE STOOLS WERE SOFTER THAN NORMAL

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
103	W. J. 4	31.5	6.75	24.8	78.6
56	J. K. 1	29.7	2.48	27.2	91.7
114	R. S. 2	27.7	2.49	25.2	91.0
153	R. S. 3	27.7	3.22	24.5	88.5
97	B. W. 1	27.6	2.54	25.1	90.8
64	L. R.	24.6	4.60	20.0	81.2
63	F. N. 2	24.1	5.09	19.0	78.8
66	P. S. 3	23.7	0.85	22.9	96.3
74	E. C. 2	21.1	2.71	18.4	87.2
173	I. P. 1	20.2	2.10	18.1	89.6
145	R. M. 1	18.5	2.81	15.7	84.8
101	J. K. 2	16.5	0.66	15.8	96.0
83	A. P.	15.1	0.65	14.6	95.7
86	J. M.	13.4	2.08	11.3	84.6
	Average.....	23.0	2.79	20.2	87.9
94	E. W.	3.4	1.09	2.3	68.3

In Table 12 is shown the retention of fat when the stools were nearly normal but contained a larger proportion of water.

In this table are seen several values for percentage retention of fat lower than any found in the two preceding tables, and the average, 87.9 per cent., is somewhat lower. A very high fat excretion is shown in three instances (Nos. 63, 64, 103); in only one of them was the intake high. Three others show very small fat excretion, but in two of them the intake was also low.

In calculating the averages in this and following tables we have not included any cases in which the intake was less than 10 gm. It is noteworthy that when the intake was below this amount the per cent. of retention in our cases was always very low.

Table 13 shows the fat retention in a group of cases which are classed together because the stools were not smooth or homogeneous, but contained fat curds or mucus, or both.

TABLE 13.—RETENTION OF FAT WHEN THE STOOLS WERE NOT HOMOGENEOUS

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
126	W. H. 4	35.8	3.35	32.5	90.7
113	J. S. 1	26.6	1.53	25.1	94.3
98	A. K.	26.4	1.61	24.8	93.9
119	W. H. 5	25.2	2.64	22.6	89.6
59	L. H.	19.8	0.69	19.1	96.5
154	W. H. 1	17.4	0.91	16.5	94.8
155	D. W. 1	17.2	3.73	13.5	78.3
82	P. L.	15.7	1.73	14.0	89.0
85	C. M.	14.4	1.64	12.8	88.8
170	R. B. 2	13.2	3.52	9.7	73.2
92	L. B.	12.5	2.06	10.4	83.5
166	A. A.	11.4	2.46	8.9	78.2
	Average.....	19.6	2.16	17.5	89.1
169	R. C. 2	9.2	3.16	6.0	65.6
160	R. C. 1	6.7	1.29	5.4	80.7
104	C. R.	0.0	0.33	....	Neg.

In this group the range of retention is wider than in the preceding, being from 73.2 to 96.5 per cent. of the intake, with an average of 89.1. There is here no essential variation from the normal either in average daily fat excretion or average per cent. of retention. The fat loss is slightly lower than that shown in the normal group; but this may be due to the lower intake.

The next group, presented in Table 14, shows the fat retention when the stools were loose.

The average per cent. of the intake retained in this group is 83.9, the range being from 71.9 to 92.8. The fat excretion several times reaches a high figure and the average is distinctly higher than in any of the preceding groups. None of the infants, however, were in a serious condition.

TABLE 14.—RETENTION OF FAT WHEN THE STOOLS WERE LOOSE

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
129	J. G. 4	32.3	4.48	27.8	86.2
107	F. H. 11	29.9	2.15	27.8	92.8
108	W. G. 3	29.8	4.32	25.5	85.5
112	W. J. 5	27.0	7.57	19.4	71.9
115	F. H. 9	26.2	2.29	23.9	91.2
116	W. G. 4	25.5	6.10	19.4	76.1
125	W. G. 2	22.5	2.85	19.7	87.3
144	V. R. 2	18.7	1.88	16.8	90.0
143	F. S.	18.7	4.20	14.5	77.6
148	W. J. 3	18.3	4.01	14.3	78.1
151	W. G. 1	17.9	2.04	15.9	88.6
159	D. F. 3	12.9	2.93	10.0	77.3
	Average.....	23.3	3.74	19.6	83.9

In Table 15 are grouped the cases in which the daily stools contained between 100 and 200 gm. of water; that is, cases which would be classed as moderate diarrhea.

TABLE 15.—RETENTION OF FAT WITH DIARRHEA

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
146	J. G. 1	39.7	7.83	31.9	80.3
136	F. H. 2	33.6	4.61	29.0	86.3
150	J. G. 2	30.7	4.77	25.9	84.5
106	V. C. 3	30.2	6.73	23.5	77.7
111	E. R. 2	27.1	3.76	23.3	86.2
102	J. G. 3	25.4	3.98	21.4	84.3
118	A. H.	25.2	4.23	21.0	83.2
161	I. P. 2	24.4	2.99	21.4	87.8
123	E. R. 3	23.4	4.97	18.4	78.7
127	D. W. 2	22.2	5.38	16.8	75.7
133	F. H. 10	20.6	2.06	18.5	89.9
135	F. H. 4	20.0	1.77	18.2	91.1
147	W. H. 3	18.4	2.10	16.3	88.6
139	J. D.	17.0	6.01	11.0	64.7
131	E. R. 1	16.8	3.35	13.5	80.1
162	D. F. 1	15.8	3.07	12.7	80.5
164	B. S. 2	15.5	3.07	12.4	80.2
165	P. V.	15.0	4.42	10.6	70.6
175	I. G.	14.7	11.62	3.1	20.8
134	D. F. 2	14.0	3.23	10.8	77.0
130	R. B. 1	13.2	2.70	10.5	79.8
142	W. J. 6	12.1	5.77	6.3	52.3
	Average.....	21.6	4.47	17.1	79.3
152	M. R.	5.4	3.61	1.8	33.3
141	F. H. 3	0.0	0.43	....	Neg.

A decided increase in the fat loss and corresponding decrease in fat retention appears. The fat retention averages 79.3. The average daily fat excretion is somewhat higher than in the preceding groups, ranging from 1.77 to 11.62 gm. The child I. G. (No. 175), who lost 11.62 gm. of fat in his daily stool, was fed on evaporated milk cooked with a considerable addition of starch. His stools were very large and showed fermentation; the appearance, however, was not that of a diarrheal stool, but the water content, 172 gm., and the total solids, 18.93 gm., were very high.

Table 16 shows the fat retention in the cases of severe diarrhea; that is, those in which the stools contained over 200 gm. of water daily.

TABLE 16.—RETENTION OF FAT WITH SEVERE DIARRHEA

Number	Case	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
132	F. H. 1	32.4	6.96	25.4	78.6
109	S. J.	29.1	14.54	14.6	50.0
120	V. C. 1	23.6	5.77	17.8	75.7
121	V. C. 2	23.6	10.38	13.2	56.1
156	W. S. 1	17.0	8.61	8.4	49.4
157	E. R. 2	11.8	5.56	6.2	53.0
176	B. S. 3	11.6	10.08	1.5	12.9
	Average.....	21.3	8.84	12.5	58.5
95	J. B.	6.4	12.58*		

* Child recently changed from higher fat intake.

This table illustrates strikingly the very great loss of fat which occurs in severe diarrheas. The smallest daily loss is over 5 gm., and the average is 8.8 gm. The retention ranges from 12.9 to 78.6 per cent. of the intake, the average being 58.5 per cent. The child, S. J. (No. 109), showed a condition similar to that of I. G. (No. 175) of the preceding table. The fat lost in the stools in this case was the greatest amount found in our entire series, being 14.54 gm. daily. The food in this case was similar to that of I. G., that is, evaporated milk with cooked starch.

The significance of the findings reported in Tables 10 to 16 is brought out more clearly if the averages of the different tables are considered together. These are given in Table 17.

TABLE 17.—SUMMARY OF AVERAGE FAT RETENTION

Table	Type of Stools	No. of Observations	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
10	Constipated.....	11	27.1	2.74	24.4	89.9
11	Normal.....	18	26.7	2.33	24.4	91.3
12	Softer than normal.....	14	23.0	2.79	20.2	87.9
13	Not homogeneous.....	12	19.6	2.16	17.5	89.1
14	Loose.....	12	23.3	3.74	19.6	83.9
15	Diarrheal.....	22	21.6	4.47	17.1	79.3
16	Severely diarrheal.....	7	21.3	8.84	12.5	58.5

We have already stated that the groups with hard and with normal stools show no essential difference in fat retention. These groups, with the highest average intake, show the highest average per cent. of retention. In fact, in the first four groups the differences in the amount of fat excreted and the per cent. of fat retained are insignificant. It is not until the stools become loose that the fat excretion becomes considerably increased and the retention correspondingly

diminished. A comparative study of the last three groups shows strikingly the effect of an increase in the amount of water in the stools. The average daily fat excretion in loose stools is at least a gram more than that of any of the four preceding groups. In the diarrheal stools the average daily fat loss is much greater, nearly twice that shown in normal stools, and in severe diarrhea it is nearly four times the normal.

Table 18 shows the fat retention of infants fed on cow's milk in comparison with that of breast fed infants. In order to obtain values comparable with those obtained for the breast fed infants in good condition, the figures in Table 10 through 14 have been averaged. This gives the average fat loss and retention of all the infants fed on cow's milk modifications whose stools were not diarrheal.

TABLE 18.—COMPARISON OF FAT RETENTION OF INFANTS TAKING COW'S MILK AND THOSE TAKING BREAST MILK

Food	Type of Stools	Intake of Fat, Gm. Daily	Fat in Stool, Gm. Daily	Fat Retained, Gm. Daily	Per Cent. of Intake Retained
Cow's milk.....	Average* (Tables 10 to 14)	24.2	2.72	21.4	88.6
Breast milk.....	Average* (Table 8)†.....	28.3	1.15	27.2	95.8

* Average of findings when the stools were of all types except diarrhea. All the children were in fairly good condition as to digestion, most of them in excellent condition.
† Preceding paper. (Fat in the Stools of Breast Fed Infants.)

The fat retention of the infants taking cow's milk averages 88.6 per cent. of the intake; of those taking breast milk it averages 95.8 per cent. of the intake. The daily loss of fat by infants fed on cow's milk is over twice as great as that lost by those taking breast milk, even though the actual amount of intake is somewhat less.

SUMMARY

1. The material presented in this article comprises the results of analysis of 128 stools of seventy-seven infants whose ages ranged from 2 to 18 months, fed on modifications of cow's milk.

2. The average fat per cent. of the dried weight in normal stools was 36.2. The hard, constipated stools showed no variation from this figure. In the stools not quite normal in appearance the average fat per cent. was slightly lower. In severe diarrhea the fat per cent. of dried weight was much higher, reaching an average of 40.7 per cent.

3. The soap per cent. of total fat was very high in both normal and constipated stools, averaging, respectively, 72.8 and 73.8 per cent. As the stools became less normal in appearance the soap fat diminished rapidly and averaged in the loose stools only 30.6 per cent. of the total fat, in the diarrheal stools 12.4 per cent., and in those of severe diarrhea only 8.8 per cent. of the total fat.

4. The neutral fat was less than 10 per cent. of the total fat in normal and constipated stools. It increased as the soap fat diminished and in diarrheal conditions made up about 60 per cent. of the total fat in the stool.

5. The free fatty acids constituted about 17 per cent. of the total fat of normal and of constipated stools. It was increased somewhat as the stools became less like the normal and in the diarrheal stools was over 30 per cent. of the total fat of the stool.

6. No definite relationship was shown between the daily fat intake and the per cent. of fat or the distribution of fat in the stool.

7. The average per cent. of the fat retained with normal stools was 91.3 per cent. of the intake. The retention was but little lower when the stools were somewhat harder or softer than normal, or were not homogeneous, or contained more or less mucus without being distinctly watery. As the water in the stools increased, the per cent. of retention dropped markedly, reaching in severe diarrhea 58.4 per cent. of the intake.

8. There was no striking relation between the fat intake and the per cent. of the intake retained, except when the intake was abnormally low.