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STUDIES ON INFANT NUTRITION

UNDER THE DIRECTION OF L. EMMETT HOLT, M.D., AND P. A. LEVENE, M.D.

*II. The Hard or Casein Curds in Infants' Stools **

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The casein curds in infant stools have been the subject of much discussion and controversy in recent years. Considerable disagreement exists in regard to both their chemical composition and the mechanism of their formation. All writers have been unanimous, however, in attributing to the curds much clinical significance, and in using them as a basis for choosing, or altering, the diet.

The older authorities regarded them as casein residues, appearing in the stools as the result of insufficient protein digestion and absorption. In recent years very emphatic protest against this view was expressed by Keller and Czerny.¹ According to their view, these curds were composed principally of a conglomeration of fat and soaps. Still more recently Biedert's² original view on the curds was revived, particularly by American writers. Selter,³ Southworth and Schloss,⁴ and Talbot⁵ made chemical analyses of the curds and on the basis of his results reached the conviction that the principal component of these masses was undigested casein. The cause of their presence in the stools lay, according to these writers, in the disturbed protein digestion. Against this view there immediately arose opposition, led principally by the school of Finkelstein. L. Meyer and Leopold⁶ did not deny the fact that the curds contained protein material, but, however, regarded the source of it not the casein of the ingested milk, but the intestinal secretions.

*From the Laboratories of the Rockefeller Institute for Medical Research, and the Babies' Hospital, New York.

1. Czerny and Keller: *Des Kindes Ernährung*, etc., 1906, part 2, 17.

2. Biedert: *Jahrb. f. Kinderh.*, 1881, xvii, 251; *Kinderernährung im Säuglingsalter*, etc., 1905, ed. 5.

3. Selter: *Versamml. Deut. Naturforsch. u. Aerzte in Stuttgart in 1907*, 177.

4. Southworth and Schloss: *Arch. Pediat.*, 1909, xxvi, 4, 241.

5. Talbot: *Boston Med. and Surg. Jour.*, 1908, clviii, No. 24, p. 905; 1909, clx, No. 1, p. 13; 1910, clxii, No. 5, 134; *Arch. Pediat.*, 1909, xxvi, No. 12, p. 919.

6. Meyer, L. F., and Leopold: *Arch. Ped.*, 1909, xxvi, No. 10, p. 773; 1910, xxvii, No. 2, p. 126.

The cause of the appearance of the curds lay, according to the view of these writers, not in insufficient protein metabolism, but in faults of the carbohydrate assimilation and was brought about by excessive carbohydrate intake. These authors maintained that the appearance of the curds in the stools could be abated when the sugar intake was lowered.

Thus all writers are in agreement on one point, namely, that the presence of the hard curds in the stools is an indication of some fault of digestion, and that the health of the infant is in danger if the curds persist in the stools. The disagreements relate only to the interpretation of the nature of the disturbance and to the mode of treatment advocated by individual writers.

A mere superficial scrutiny of the literature on the subject reveals the fact that even the gravity of the symptom has never been firmly established; it was an assumption based on speculative considerations. Taking this assumption for granted, the individual observers applied their efforts in search for a method of treatment by which the symptom could be abated. The interpretation of the pathogenesis of the symptom was then determined by the success or failure of a certain mode of treatment. Thus, if the removal, complete or partial, of carbohydrate from the diet led to the disappearance of the curds, the theory was advanced that the disturbance of carbohydrate digestion was the basic cause of this symptom. Arguments of this nature can scarcely be regarded as very convincing. On the other hand, it was never clearly demonstrated that there existed a definite form of indigestion which invariably resulted in the curd formation in the stools, and still less evidence existed in favor of the assumption that the nutrition of the infants was affected severely in the periods when the stools contained the curds in abundance.

New experimental inquiry was needed in order to obtain reliable information on all these questions, and the present work was stimulated by such considerations.

Thus it is natural that the work should fall into two parts, one dealing with the relation of the curds to the state of digestion, and the second to that of nutrition. Information relating to the first part of the problem was sought on the grounds of the following reasoning: If the curds represent the remnants of undigested food, then their composition should be determined by the nature of the digestive insufficiency. Thus, if the curds consist principally of one component, of protein, of fat, or of carbohydrate, the conclusion would follow that there existed an insufficiency in the digestive capacity for that food-stuff. If that were so, one should also find that the composition of the entire stool showed a preponderance of that same component. On the other hand, should the curds have exactly the composition of normal stools differing only in the water content, the assumption may be justified that their formation

is conditioned by irregularities of peristalsis. Finally the mass of the stools may, under some forms of indigestion, acquire such peculiarities of composition as would lead to the separation of one of its constituents in solid form. Thus, the accumulation of calcium salts may result in separation of lime-soaps; unusually high acidity may bring about precipitation of nucleins. Under such conditions one should expect the curds to have a composition distinctly different from that of the remainder of the stools, but would expect also a definite constant composition of the stool as a requirement for the curd formation.

From these considerations it is evident that it is not sufficient to limit the chemical investigation to the composition of the curds except when it is desired to establish the relationship between the state of digestion and the curd formation. On the contrary, it is very essential to supplement the analysis of the curds by that of the total stools. Furthermore, the insufficiency of the digestive organs may be essentially quantitative in its nature. That is, it may occur only after the intake of a certain constituent of the daily diet has overstepped a certain limit. Thus in order to be able to take into account all the factors engaged in the curd formation it is necessary to possess the knowledge of the chemical composition of the food, of the curds, and of the total stool in which they occur.

The data furnished by such analyses suffice to bring to light the bearing of any gastro-intestinal disturbance on curd formation, but they cannot help to interpret the influence of the curd formation on the state of general nutrition. It has been stated that there exists no experimental evidence in support of the view that the curds in infants' stools are indicative of some serious disturbance of nutrition. And yet the importance of the entire problem of curd formation depends on the answer to this question. In order to approach the solution of this problem the analyses of the food, of the curds, and of the total stools were supplemented by that of the urine, so that at least in regard to the nitrogen the exact daily balance could be established. Taking into account, in addition to this, the curve of the daily gain in weight, one can obtain fair information as to the general state of nutrition during the periods when the stools showed the greatest number of curds.

One other possibility needs to be analyzed before the discussion on the significance of the curds is exhausted, namely: Assuming that the curds represent a part of the ingested food which escaped digestion, one can easily recognize that the gravity of this condition would depend on the proportion of the food which escapes in that form. If the loss is considerable then normal nutrition could be maintained only by a corresponding increase in the daily diet. This information can be obtained by an estimation of the quantities of food elements contained in all the

curds present in a twenty-four-hour sample of the stools. Naturally the curds have to be cleansed very carefully from the adhering feces. Such analyses were carried out in the course of the present investigation. They are recorded in Table 2.

Before passing to the report on the results of the present investigation it seems necessary to describe the general character of the curds, which are referred to in the present communication. It has been pointed out by several writers that much of the controversy in regard to the significance of the curds has resulted from the fact that writers were not sufficiently explicit in describing the appearance and the physical properties of the curds, and while some were dealing actually with fat-curds, other writers had under their observation curds of an entirely different composition. The curds referred to in the present paper possessed great similarity in their physical properties, though they differed considerably in their form.

Physical Character of the Curds.—Very commonly they consisted of rather hard, round or oval, not infrequently bean-shaped masses. Often they presented masses tapering at one end, or flattened into thin plates. The surface was generally smooth. The size varied from small fragments to masses more than an inch in length. The weight of such curds reached 2 gm. In several cases the combined curds obtained from a twenty-four-hour sample of feces (three or four large and two or three smaller masses) weighed between 7 and 8 gm. The surface was frequently stained deep yellow, while the inner part was usually white or cream-colored, more rarely yellow. In a few instances they presented a shining surface, persistent even after careful washing. Very often more or less numerous small fragments of the same material as the hard curds were found in the stools, either with or without the larger masses, possibly resulting from disintegration of the latter. These hard curds have the common characteristic of being more or less tough and resistant to pressure, and can thus be distinguished from the so-called fat-curds. The latter are generally soft and small in size.

On one occasion there was obtained a smooth, oval, moderately hard mass about $1\frac{1}{4}$ inches in length, which became liquid during the drying on a water-bath. On analysis it was found to contain over 80 per cent. of fat and between 1 and 2 per cent. nitrogen. Macroscopically it differed from the typical hard curds only in yielding more readily to pressure and in showing a smoother texture. The feces of the same child contained for a long period previous to that day the characteristic casein curds.

Chemical Composition.—Results of complete analysis of the curds are recorded by Selter³ and by Talbot.⁵ The total number of samples analyzed was eight, one by Selter and seven by Talbot. In regard to the protein content, there was an approximate uniformity in all the

Number	Name	Date	Food Composition *							Composition of Curds Per Cent. of Dried Weight of Curds				Description of Stools Containing Curds
			Protein, Per Cent.	Fat, Per Cent.	Carbohydrate, Per Cent.	Nitrogen, gm.	Fat, gm.	Carbohydrate, gm.	Total Calories	Nitrogen	Protein	Fat	Ash	
1.	E. A.	Nov. 1910	51.75	...	5	3.02	....	54.0	334	9.8	61.2	20.0	...	Pasty; granular, yellow-green.
2.	A. P.	91.2	1.4	1.4	6	2.02	14.7	63.0	465	10.5	65.6	22.5	4.8	Pasty; granular, green-yellow, sour.
3.	S. R.	261.4	1.6	5.7	5.7	2.35	16.8	59.9	487	10.6	66.2	25.1	...	Loose; granular, green.
4.	W. E.	72.3	.9	2.6	2.6	3.31	8.1	23.4	304	10.6	66.2	22.3	4.8	Loose-watery; granular, green.
5.	H. C.	71.8	.9	5	2.72	8.5	47.2	376	11.3	70.5	...	...	6.5	Pasty; granular, with mucus, green-yellow.
6.	H. S.	71.8	.9	2.25	3.03	9.5	23.6	307	10.6	66.2	19.0	...	4.8	Pasty; smooth-granular, green-yellow.
7.	P. C.	121.6	1.8	7.8	2.42	17.0	73.6	544	9.9	61.8	29.5	...	5.0	Pasty; smooth, pale yellow-green, sour.
8.	I. W.	161.4	1.6	5.7	2.35	16.8	59.9	487	9.5	59.3	...	...	...	Pasty; smooth-granular, yellow-green.
9.	T. S.	201.75	2.0	5	3.03	21.6	54.0	538	9.0	56.2	22.0	...	4.8	Pasty; smooth, yellow becoming green-brown, sour.
10.	T. S.	211.75	2.0	5	3.03	21.6	54.0	538	8.8	54.9	22.0	...	4.8	Loose-pasty; granular, green and yellow.
11.	T. B.	301.4	1.6	5	2.35	16.8	52.5	459	10.1	63.1	...	...	4.8	Pasty; granular, yellow becoming green.
12.	C. R.	Mar. 1911 7-8	...	2.65	3.45	...	...	27.8	251	11.4	71.2	18.8	...	Loose; smooth, with mucus, yellow-brown becoming green.
13.	J. H.	13-14	...	...	...	...	...	...	...	...	...	...	...	Pasty; smooth, pale gray-yellow, slightly green.
14.	J. H.	14-15	2.0	2.9	5	3.54	32.1	55.3	663	10.1	63.1	...	...	Loose-pasty; smooth, pale yellow, slightly green.
15.	J. H.	17-21	2.0	1.8	5	3.54	19.9	55.3	549	9.4	58.7	...	...	Loose-pasty; mostly smooth, green-yellow and yellow-gray.
16.	J. H.	21-22	2.2	2.0	5	4.07	23.1	57.7	609	8.8	54.9	...	...	Loose-pasty; smooth, yellow becoming white-gray and pale green.

No. *Food

1. Fat-free milk 50 per cent., lime-water 5 per cent., barley-water 45 per cent., lactose 5 per cent. Food boiled.
2. Milk 35 per cent., lime-water 5 per cent., barley-water 60 per cent., lactose 5 per cent., and 12 c.c. malt-soup extract.
3. Milk 40 per cent., lime-water 5 per cent., barley-water 55 per cent., lactose 5 per cent., and 8 c.c. malt-soup extract.
4. Mixture of full milk, fat-free milk, 5 per cent. lime-water and barley-water making milk fat 0.9 per cent., lactose 2.6 per cent.
5. Skimmed milk 50 per cent., lime-water 5 per cent., barley-water 45 per cent., lactose 5 per cent.
6. Skimmed milk 50 per cent., lime-water 5 per cent., barley-water 45 per cent., lactose 2.25 per cent.
7. Milk 45 per cent., lime-water 5 per cent., barley-water 50 per cent., lactose 5 per cent., 30 c.c. malt-soup extract.
8. Milk 40 per cent., lime-water 5 per cent., barley-water 55 per cent., lactose 5 per cent., 8 c.c. malt-soup extract.
9. Milk 50 per cent., lime-water 5 per cent., barley-water 45 per cent., lactose 5 per cent.
10. Same as in No. 9.
11. Milk 40 per cent., lime-water 5 per cent., barley-water 55 per cent., lactose 5 per cent.
12. Fat-free milk 55 per cent., lime-water 5 per cent., water 35 per cent., lactose 2.65 per cent.
- 13 and 14. Mixture full milk, fat-free milk, lime-water 5 per cent., and barley-water making milk fat 1.8 per cent., lactose 5 per cent., olive-oil 12 c.c.
15. Same as in Nos. 13 and 14, with olive-oil omitted.
16. Similar mixture to that in preceding numbers, but making milk fat 2 per cent, lactose 5 per cent.

curds. Regarding the fat content Talbot recorded a considerable variation in different samples. According to this observer, the fat content of the curds was determined by that of the food. In the course of the present observations more than thirty samples of curds were analyzed. Great care was taken to free the curds from adhering feces. This was accomplished by shaking them with water. The wash waters were removed by decantation, and the curds dried and used for analysis. The chemical analysis of these masses revealed a similarity in their composition which cannot be regarded as accidental. It is clearly seen from the tables that the protein, fat and ash content fluctuated within very narrow limits.

On the other hand, the composition of the stools was very variable, the nitrogen content fluctuating between 3, 4 and 5 per cent., only in one instance reaching 5.5 per cent., and in another 6 per cent.; the proportion of fat varied from 26 to 48 per cent., the ash between 20 and 31 per cent. The total acidity of the feces and the content of volatile acids also presented great variations.

Thus it is evident that the hard curds are composed differently than the mass of the stools and not infrequently contain more than 75 per cent. of protein. On this ground they cannot be regarded as masses of feces compressed into the peculiar formations owing to some irregularities of intestinal motility. They therefore represent either remnants of food that escaped normal digestion, or a normal component of the feces separated out of the mass of the stools owing to some peculiarity of the composition of the latter. The fact that the chemical nature of the feces that contained the curds differed very markedly lends more support to the first of the two hypotheses, namely, that the curds represent remnants of undigested food, principally protein.

This naturally leads the inquiry into the causes of this partial indigestion. It has to be admitted that a very definite answer to this question cannot be given notwithstanding all the data furnished by the present work.

The great variations in the chemical composition of the stools which show the presence of curds argue against the assumption that there exists one definite form of indigestion which brings about the curd formation. To the same conclusion one is led by the analysis of the influence of diet on the appearance of curds. It is clearly seen from Table 1 how varied the diet may be which renders possible the formation of curds in the feces. And still the impression is gained that the protein intake is a very significant factor in bringing about this symptom. Particularly the metabolism experiment on Daniel L. seems to furnish evidence in support of this view. This patient was under observation for considerable time and his diet was altered several times. It was observed that the curds

TABLE 2.—COMPOSITION OF HARD CURDS (FROM TWENTY-FOUR HOURS' FECES)

Number	Name	Date	Food Composition *						Dried Weight of Stools, Including Curds, gm.	Dried Weight of Curds, gm.	Output, Per Cent. of Dried Weight of Curds				Description of Stools Containing Curds
			Protein, Per Cent.	Fat, Per Cent.	Carbohydrate, Per Cent.	Nitrogen, gm.	Fat, gm.	Carbohydrate, gm.			Nitrogen	Protein	Fat	Ash	
1.	D. L.	Dec. 1910	2.1	1.8	5	4.58	24.6	68.3	12.13	1.00	9.0	56.2	23.3	...	Pasty; constipated, smooth, yellow-gray
2.	D. L.	6-7									10.1	63.1	23.3	...	Loose-pasty; smooth, yellow, green flakes.
3.	D. L.	7-8									10.2	63.7	24.0	4.6	Pasty; smooth, yellow becoming green.
4.	D. L.	12-13									10.4	65.0	24.0	4.6	Pasty; constipated, smooth, yellow becoming gray-brown.
5.	D. L.	13-14	1.8	1.2	5	3.94	16.4	68.3	11.18	2.80	11.0	68.7	24.0	4.6	Pasty; part granular, yellow becoming green, part smooth, brown.
6.	D. L.	15-16									1.3	8.1	81.5	14.7	Pasty; constipated, smooth, yellow becoming gray-brown, with mucus, small hard curds and one large fat lump.
7.	D. L.	17-18									10.9	68.1	24.0	4.6	Pasty; smooth, yellow becoming gray-brown.
8.	D. L.	18-19	1.8	1.2	5	3.33	13.9	57.8	6.30	.45	11.5	71.9	19.6	6.3	Pasty; constipated, smooth, yellow becoming gray-brown.
9.	R. M.	14-15									10.9	68.1	19.6	6.3	Pasty; constipated, smooth, yellow becoming gray-brown.
10.	R. M.	16-17									10.9	68.1	19.6	6.3	Pasty; constipated, smooth, yellow becoming gray-brown.
11.	J. D.	18-19	2.1	1.8	5	3.53	18.9	52.5	5.58	.10	10.5	65.6	30.0	4.0	Pasty; constipated, smooth, yellow becoming gray-brown and slightly green.
12.	J. D.	7-8									10.63	3.15	65.6	30.0	Pasty; finely granular, smooth, yellow becoming green, sour.
13.	J. D.	9-10									10.33	2.90	62.5	30.0	Pasty; partly granular, smooth, yellow becoming green, partly smooth, yellow becoming white.
14.	J. D.	12-13	1.8	1.2	5	3.33	13.9	57.8	8.92	3.65	10.8	67.5	30.0	4.0	Pasty; smooth, yellow becoming gray-brown.
15.	J. D.	14-15									11.5	71.9	30.0	4.0	Pasty; mostly granular, yellow becoming green, partly smooth, yellow becoming white and green.
16.	J. D.	15-16									10.5	65.6	30.0	4.0	Pasty; smooth, green and yellow, becoming brown and green.
17.	J. D.	17-18	1.8	1.2	5	3.33	13.9	57.8	6.22	1.30	11.1	69.3	30.0	4.0	Pasty; part smooth, yellow becoming brown, white and green, part granular, green and sour.
18.	J. D.	18-19									10.98	4.65	30.0	4.0	Pasty; part smooth, yellow becoming green and brown, part granular and green.

* Food.—Nos. 1, 2, 11, and 12.—Mixture full milk, fat-free milk, 5 per cent. lime-water and water making milk fat 1.8 per cent.; lactose 5 per cent.
In all other numbers, mixture full milk, fat-free milk, 5 per cent. lime-water and water making milk fat 1.2 per cent.; lactose 5 per cent.
† Fat lump only, small hard curds not separated from stool.

appeared in the highest number and more continually when the percentage of protein intake reached the highest values. The only period when the stools were free from curds was when both the fat and protein intake were low and the carbohydrate intake comparatively high. The variation in fat intake alone remained without influence on the curd formation.

TABLE 3.—COMPOSITION OF STOOLS CONTAINING HARD CURDS—FECES WITHOUT THE CURDS

Name	Date	Total Nitrogen, gm.	Per Cent. of Dried Weight of Feces					Soap Fat, Per Cent. of Total Fat	C.c. N/10 NaOH Equivalent			
			Nitrogen	Protein	Fat	Soap Fat	Ash		Total Acidity of Feces	Volatile Acids of Feces	100 gm. Dried Weight Feces	
											Total Acidity	Acids Volatile
	Dec. 1910											
D. L.	6-7	.592	4.9	30.6	29.7	19.2	26.4	64.6	45.2	103.5	406	930
D. L.	7-8	.782	5.5	34.4	30.4	11.4	22.6	85.2	85.2	112.9	599	794
D. L.	12-13	.278	3.4	21.2	45.0	25.3	19.8	56.3	38.9	44.8	804	1,010
D. L.	13-14	.531	6.0	37.5	36.9	17.5	25.9	42.3	17.7	172.9	199	1,947
D. L.	15-16	.407	4.8	30.0	36.2	16.3	25.2	45.2	6.8	47.6	354	2,386
D. L.	17-18	.226	4.3	26.8	33.6	16.6	24.2	49.3	3.4	47.3	121	1,771
D. L.	18-19	.282	4.8	30.0	36.9	17.5	25.9	42.3	4.9	88.3	83	1,510
R. M.	14-15	.376	4.5	28.1	33.6	25.3	29.4	75.3	8.4	179.9	100	2,144
R. M.	16-17	.618	4.8	30.0	33.6	25.3	29.4	75.3	4.1	36.8	52	437
R. M.	18-19	.285	5.2	32.5	33.6	25.3	29.4	75.3	5.7	43.7	104	798
J. D.	7-8	.288	3.8	23.8	46.2	26.3	20.9	56.9	33.6	77.8	448	1,040
J. D.	9-10	.311	4.2	26.2	43.0	31.2	21.2	72.6	31.4	92.7	422	1,248
J. D.	12-13	.230	4.4	27.5	48.8	38.7	21.4	79.3	10.2	83.3	332	2,724
J. D.	14-15	.198	4.0	25.0	37.7	19.7	25.1	52.2	12.0	65.2	569	3,697
J. D.	15-16	.236	5.1	31.8	36.3	24.5	19.3	67.5	20.2	58.1	580	1,909
J. D.	17-18	.263	4.3	26.8	45.1	33.9	22.8	75.3	4.7	30.0	236	1,736
J. D.	18-19	.201	4.7	29.4	38.1	26.6	20.3	69.8	7.7	68.8	354	3,533
	March, 1911											
J. H.	13-14	.141	4.5	28.1	26.8	15.8	26.4	59.0				
J. H.	14-15	.164	4.3	26.8	32.4	19.2	31.2	59.3				
J. H.	17-18	.094	3.8	23.8	48.6	35.9	25.3	73.9				
J. H.	18-19	.170	4.1	25.6	31.5	13.2	22.5	41.9				
J. H.	19-20	.136	3.9	24.4	28.0	8.1	23.0	23.9				
J. H.	20-21	.245	3.8	23.8	35.4	16.7	28.3	47.2	17.5	44.8	270	693
J. H.	21-22	.247	3.3	20.6	48.3	5.0	24.2	10.4	23.1	72.4	311	976
J. H.	22-23	.123	3.7	23.1	39.8	15.9	20.6	39.9				

Thus it seems probable that under a variety of conditions, part of the protein intake escapes being digested and is removed by the stools in form of hard curds. The real mechanism of the curd formation is not easy to interpret for the reason that normally protein enters the intestinal canal from the stomach in a state of solution, and even if some of it enters in solid form the proteolytic enzymes of the pancreas are capable of bringing it into solution. If the protein is of the nature of a nuclein or paranuclein, as, for instance, casein, the alkalis present in the intestinal tract should be capable of effecting its solution. There is undoubt-

edly a sufficient supply of proteolytic enzymes in the intestinal canal even under the conditions favorable to abundant curd formation, for the reason that often only a comparatively small part of the ingested protein appears in the stools in that form, the greatest part having apparently undergone normal digestion. Thus there must be some factors at play, which prevent the enzymes from penetrating the curd. No definite explanation of their nature can be offered at the present moment.

TABLE 4.—COMPOSITION OF STOOLS CONTAINING HARD CURDS—FECES INCLUDING THE CURDS

Name	Date	Feces. Dried Wt. in gm.		Total Nitrogen, gm.	Total Fat, gm.	Total Ash, gm.	Per Cent. of Dried Weight of Feces			
		With Curds	Without Curds				Nitrogen	Protein	Fat	Ash
	Dec. 1910									
D. L.	6-7	12.13	11.13	.682	3.53	2.99	5.6	35.0	29.3	24.6
D. L.	7-8	17.82	14.22	1.146	5.16	3.61	6.4	40.0	28.9	20.3
D. L.	12-13	11.20	8.35	.567	4.47	1.79	5.1	31.9	39.9	16.0
D. L.	13-14	9.88	8.88	.635	3.52	2.35	6.4	40.0	35.7	23.8
D. L.	15-16	11.18	8.38	.719	3.72	2.24	6.4	40.0	33.3	20.0
D. L.	17-18	6.02	5.32*	.235	2.37	1.39	3.9	24.4	39.3	23.0
D. L.	18-19	6.30	5.85	.331	2.27	1.53	5.3	33.1	36.1	24.4
R. M.	14-15	8.69	8.39	.411	2.88	2.48	4.7	29.4	33.2	28.5
R. M.	16-17	13.84	12.94	.716	4.52	3.85	5.2	32.5	32.6	27.8
R. M.	18-19	5.58	5.48	.296	1.86	1.62	5.3	33.1	33.3	28.9
J. D.	7-8	10.63	7.48	.619	4.41	1.70	5.8	36.2	41.3	15.9
J. D.	9-10	10.33	7.43	.603	4.07	1.69	5.8	36.2	39.3	16.3
J. D.	12-13	8.92	5.27	.625	3.67	1.28	7.0	43.7	41.1	14.3
J. D.	14-15	6.22	4.92	.347	2.21	1.30	5.6	35.0	35.6	20.8
J. D.	15-16	6.23	4.68	.399	2.16	.970	6.4	40.0	34.7	15.5
J. D.	17-18	10.98	6.33	.775	4.14	1.67	7.0	43.7	37.8	15.2
J. D.	18-19	6.67	4.12	.471	2.30	.920	7.1	44.4	34.5	13.8
	March, 1911									
J. H.	13-14	4.05	3.15	.225	1.042	.882	5.6	35.0	25.7	21.7
J. H.	14-15	4.55	3.80	.239	1.396	1.225	5.3	33.1	30.7	27.0
J. H.	17-18	3.20	2.50	.161	1.295	.670	5.0	31.2	40.4	20.9
J. H.	18-19	4.70	4.20	.217	1.380	.973	4.6	28.8	29.4	20.7
J. H.	19-20	4.20	3.50	.201	1.057	.844	4.8	30.0	25.2	20.1
J. H.	20-21	6.88	6.48	.282	2.340	1.853	4.1	25.6	34.0	27.9
J. H.	21-22	7.91	7.41	.291	3.632	1.818	3.7	23.1	46.0	23.0
J. H.	22-23	3.45	3.35	.132	1.343	.696	3.8	23.8	38.9	20.2

*Fat lump only separated, few small hard curds left in the feces.

It remains to discuss the data regarding the practical significance of the symptom. It has been stated before that the curds represent part of the food that has escaped being digested. It naturally follows that the injury occasioned by it to the economy of the organism may be very perceptible when the proportion of the non-utilized fraction reaches a high value. The review of Table 2 clearly demonstrates that such may be the case only on very rare occasions. Thus it is seen that out of seventeen stools, in nine the curds contained less than 1 gm. and not more

than 1.5 gm. of dry material. Calculating their protein content at 65 per cent., the loss of protein occasioned by the curd formation in these nine instances ranged between 0.06 and 0.95 gm. in twenty-four hours. In four stools the total dry weight of the curds reached from 2.0 to 3.0 gm. This resulted in a protein loss varying between 1.35 and 2.0 gm. in twenty-four hours. In four other stools the dry weight of the curds was between 3.15 and 4.65 gm., which meant a loss of protein of from 2 to 3 gm. Calculating the twenty-four-hour intake at 20 gm., it becomes evident that only on very few occasions was the loss resulting from the curd formation considerable. Generally, however, the appearance of curds in stools in itself does not lead to a perceptible decline in the utilization of the food-stuffs.

Furthermore, this conclusion is corroborated by the metabolism experiments. It is seen from Table 5 that the largest mass of curds was formed in the fifth period, which coincided with the period of the largest nitrogen retention. Of the two periods, fourth and fifth, with about equal protein intake, the mass of the curds was greater when the carbohydrate intake was of a lower, and the fat intake of a higher value. Comparing further the calorific value of the diet of the fourth and fifth periods, in which the protein intake was unchanged, one notices that in the fourth period the food utilization was less perfect, and yet it led to the formation of a smaller mass of curds.

On the other hand, the stools were completely free from lumps in the second period. In that period the food intake was of a comparatively lower calorific value, and in proportion to other food-stuffs rich in carbohydrates and very poor in protein. The retention of nitrogen in that period was very insignificant. In other words, the state of nutrition was in a less perfect condition when the stools were free from curds.

CONCLUSIONS

1. The "hard" or "casein" curds represent remnants of food, principally of protein nature, that have escaped being digested.
2. The exact mechanism of their formation as yet cannot be ascertained and they should be regarded as a peculiarity appearing in course of imperfect conditions of digestion.
3. The curds are not pathognomonic of any definite pathologic condition.
4. The loss of food occasioned by their formation and the impairment of the general nutrition resulting from it is insignificant.
5. In attempting to correct the state of digestion one should be guided by the general rules of infant feeding, paying only secondary attention to the appearance or disappearance of curds from the stools.

TABLE 5.—DANIEL L. PROTEIN RETENTION*

Number	Date	Intake in gm.			Intake in Per Cent.			Output		Daily Average Nitrogen				Average Daily Gain in Weight	Description of Feces
		Carbohydrate, gm.	Fat, gm.	Nitrogen, gm.	Carbohydrate, Per Cent.	Fat, Per Cent.	Protein, Per Cent.	Urine, gm.	Feces, gm.	Absorbed, gm.	Retained, gm.	Absorbed, Per Cent.	Retained, Per Cent.		
	Oct.														
1.	1910 15-25	55.34	16.1	2.109	5.0	1.4	1.2	1.496	0.456	1.6.1	0.155	78.3	9.4	—	Partly pasty, smooth, gray-yellow and brown-yellow, partly watery; granular, green-brown. Hard curds present on three days.
2.	25-28	73.85	14.5	1.759	6.0	1.2	1.0	1.377	0.321	1.438	0.061	81.8	4.2	+12.3	Mostly formed and brown; a little thinner and green-brown. No hard curds present.
3.	Nov. 8-15	95.0	27.4	3.618	7.4	2.2	2.0	1.651	0.946	2.672	0.981	84.5	32.1	+28.7	Partly formed, smooth, brown; partly thinner, granular, yellow. Hard curds present on four days.
4.	15-22	84.04	18.0	4.831	6.3	1.0	2.55	3.201	0.809	4.022	0.821	83.3	20.4	+15.1	Like the feces of preceding period, generally more watery. Hard curds present every day, often large curds.
5.	Dec. 6-10	56.05	20.5	4.765	5.0	1.8	2.1	2.709	1.005	3.760	1.051	77.9	28.3	—	Mostly loose-watery (first day only formed), granular, with nucleus, green-yellow, many large hard curds, some present every day.

*Composition of Food

No.

- 35 per cent. milk, 5 per cent. lime-water, 60 per cent. water, milk-sugar to 5 per cent.
- 30 per cent. milk, 5 per cent. lime-water, 65 per cent. barley water, milk-sugar to 5 per cent., 12 c.c. malt-soup extract.
- 55 per cent. milk, 5 per cent. lime-water, 40 per cent. water, milk-sugar to 5 per cent., 30 c.c. malt-soup extract.
- Fat-free milk 20 per cent., skimmed milk 55 per cent., lime-water 5 per cent., water 20 per cent., milk-sugar to 5 per cent., 16 c.c. malt soup extract.
- Fat-free milk and full milk, 5 per cent. lime-water and water to make milk fat 1.8 per cent., milk protein 2.1 per cent., milk-sugar to 5 per cent.

After the present communication was completed for publication there appeared a paper by Brennemann⁷ on the etiology and nature of hard curds. On the basis of many observations the author was led to the conclusion that curds appear in stools only after feeding on raw milk, and that the curds disappear as soon as the diet is changed to boiled milk. Brennemann takes for granted that the appearance of curds is the result of a serious fault of digestion, which can be corrected by changing the diet from raw to boiled milk. The observations of Brennemann may prove of practical and theoretical importance, but his work fails to furnish new information as to the clinical significance of the appearance of the curds. The present observations may be of some value whether or not the views of Brennemann are corroborated.

Without any desire to contradict, or to disagree with the views expressed by this writer, attention may be called to the fact that the first patient under our observation was fed on boiled milk.

METHODS OF ANALYSIS

Total Nitrogen was determined by the Kjeldahl-Gunning method. Samples of food mixtures, feces, and curds were dried on a water bath and then to constant weight in an air bath.

Sugar estimation was made volumetrically by the method described by Ettore Selvatici.⁸ The procedure was the following: The proteins of the milk were removed by coagulation, and the clear filtrate was added from a burette into a definite volume of a boiling Fehling's solution. A small amount of potassium ferrocyanid is added to Fehling's solution previous to the beginning of titration. The sugar solution is added until the Fehling solution loses its blue color.

Starch content in barley water, barley jelly, and bean gruel was determined by its inversion into glucose. This was accomplished by heating the solution with dilute sulphuric acid in an autoclave. The sugar was titrated by the Pavy method.

Fat estimation was made by extraction with ether in a Soxhlet apparatus. For the determination of the total fat, the substance to be extracted was carefully mixed with phosphoric acid. Fat exclusive of soap fat was estimated directly on the unmixed feces. In the food, fat was estimated by extracting with ether in a Soxhlet apparatus. In order to remove the moisture from the ether extracts, the residues of these extracts were redissolved in chloroform, filtered through paper moistened with chloroform, and dried first on a water bath and then in a desiccator.

7. A Contribution to Our Knowledge of the Etiology and Nature of Hard Curds in Infants' Stools, *AM. JOUR. DIS. CHILD.*, 1911, i, 341.

8. Selvatici, Ettore: *Bul. de l'Assn. des Chimistes de sucrerie et de distillerie*, 1910, xxvii, 1179.

Ash-Estimation.—The dry samples of food or excretions were incinerated and the residue extracted with hydrochloric acid. The insoluble part was further ignited with the use of a few drops of strong nitric acid. The acid filtrate was added to the residue and evaporated to dryness.

The total acidity and volatile acids in the feces were determined in the following way: A known proportion of the moist feces was made into an emulsion by shaking in distilled water with glass beads, and then made to definite volume. An aliquot part was titrated for total acidity with decinormal sodic hydrate, phenolphthalein being used as indicator. To determine volatile acids, another portion of the emulsion was made acid to congo paper with dilute phosphoric acid and distilled with steam into a measured quantity of decinormal sodic hydrate until the dropping distillate was no longer acid; the unneutralized sodic hydrate then being titrated with decinormal sulphuric acid and phenolphthalein used as indicator.

HISTORIES

Daniel L., 7 months old, was admitted to the hospital Oct. 5, 1910. There was a history of protracted diarrhea and no gain in weight. He weighed 10 pounds, 8 ounces and was poorly nourished. Metabolism experiments were carried on from October 15 through October 28, from November 8 through November 22, and from December 6 through December 10, and the stools were collected for analysis until December 19. During the first period the weight was variable, being about the same at the end as at the beginning, 4,722 gm. The temperature was also variable. During the second period the child was looking well and the weight increased rather steadily from 5,003 grams to 5,310 grams. In the last period the weight was again variable, showing a slight loss at the end of the metabolism experiment and a small increase during the following days in which the stools were collected. During this time the child had low, irregular fever due to a cervical adenitis, which continued for some time after the conclusion of the experiment, accompanied by loose stools and falling weight. Subsequently the food was changed to one with less fat and protein and high carbohydrate with marked improvement and gain in weight.

Richard M., 2½ months old, was admitted to the hospital Sept. 6, 1910. He had not been gaining weight, and for ten days had had diarrhea with fever and some vomiting. He was poorly nourished but not emaciated, weighing 9 pounds, 6 ounces. He was used as a control for the Daniel L. experiments, his stools being collected from October 16 through October 28, November 8 through November 22, and December 6 through December 19. During all this time he showed a generally rising weight-curve, from 4,527 gm. on October 16 to 5,063 gm. on December 19. After the first period the stools were very good, though they frequently contained small hard curds, rarely large or numerous ones. He was discharged December 25, gaining and in good condition.

John D., 2½ months old, was admitted to the hospital Sept. 27, 1910, with a history of diarrhea and loss in weight. He was emaciated and rachitic. His weight was 5 pounds, 11 ounces. He began to gain almost at once and his stools improved. Successive increases were made in his food as his weight became stationary, on October 11, October 22, November 8, November 16, and November 23. Between November 8 and November 16 a peri-rectal abscess formed and he had fever but still continued to gain in weight. December 3 large hard curds began to appear in his stools. From December 6 through December 19 the stools were collected for analysis. During this time his stools were generally good, though they contained many large hard curds, and his weight increased from

3,508 gm. December 6 to 3,584 gm. December 18. Double otitis media developed from December 5 and erysipelas of the scalp from about December 18, with more or less fever, and he began losing weight. He was well of the erysipelas by December 29, but one ear was still discharging at that time. The gain in weight began when he was placed on a milk formula with low fat and protein and relatively high sugar.

Joseph H., 9 months old, was admitted to the hospital Feb. 6, 1911, weight 8 pounds, 3½ ounces. There was a history of constipation and considerable colic, and recently, vomiting and loss of weight. He was rather poorly nourished. There was no vomiting after admission but his weight remained at a standstill until February 24, when his food was increased. He served as a metabolism control from March 14 through March 23. During the experiment he gained slightly in weight, from 3,955 gm. to 3,994 gm. and had good stools, which, however, invariably contained hard curds, often large and numerous ones. He continued to gain in weight and have good stools and was discharged April 23, weighing 4.583 gm.