Chapin (H. D.)

Studies in Infant Feeding.

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Professor of Diseases of Children at the New York Post-Graduate Medical School and Hospital.

A Food for Infants, with Experiments, Chemical and Physiological.

BY

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STUDIES IN INFANT FEEDING.*

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There are certain requisites for an infant's food before it can be recommended for general use. Thus, it must be readily procurable under the common and ordinary conditions of life; it must be digestible, nourishing, and fairly cheap. The mixing or preparation of such a food must not be too complicated. The conditions here mentioned can only be met by employing cow's milk, more or less diluted or altered, according to the necessities of the case. The following paper contains no new principles, but is rather a record of experience in the simplest manipulation of cow's milk to make it most acceptable to the infant's stomach and digestion. The clinical experience has been principally derived from the babies' wards of the New York Post-graduate Hospital, where the infants are subjected to close scrutiny and constant weighings during periods varying from several days to as many weeks, and sometimes even longer. Those who have had a large dis-

* Read before the Section in Pædiatrics of the First Pan-American Medical Congress.

pensary and hospital experience in artificial infant feeding among the poor can not have failed to notice the frequent tendency to atrophy. This is often so extreme as to cause death. Even in cases not so marked there is almost universally present a condition of underweight. Many unfavorable hygienic conditions favor this deplorable result, but the principal cause is the nature and quality of the food that is administered. This grave tendency toward atrophy should constantly be borne in mind in all studies bearing on artificial infant feeding.

The milk as ordinarily delivered on a given morning in New York, and doubtless in other large cities, consists of a mixture resulting from the milkings of the previous morning and the night preceding, thus being from twenty-four to thirty-six hours old. If the milk dealer knows his farmers, he can sometimes induce them to put the twenty-four hour's milk in a can by itself, which is a gain as regards infant feeding. What is urgently needed is more scrupulous cleanliness in the handling of the cows and milk upon the farm, and quicker and more frequent methods of transportation of the milk to town in order to represent a real gain in the feeding of infants. It need hardly be mentioned that the average milk from a herd of cows is better and safer than the traditional one cow's milk. As soon as the milk is received in the early morning it is put in a tin pail or wide-mouthed vessel that is covered and allowed to stand in a cool place for three hours. The top half only of this milk is to be administered to the infant, as advised by Dr. Meigs. This top portion is best separated by being carefully dipped off by a cup or ladle. If decanted, both layers of the milk will become mixed by the lower part rising when the vessel is tipped. At the babies' wards a long glass cylinder is employed, which is graduated and furnished with a stopcock at the bottom. After standing

the required time, a distinct difference is noted in the two portions of the milk, which are easily separated by drawing off the lower half and reserving the remainder for the infant's use. In order to learn exactly what difference the simple process of standing would make, the two parts of the milk were analyzed with the following results: One gallon was drawn from the bottom of the cylinder, well mixed, and a sample taken which showed:

Fat (1)	3·0 per cent.	Total solids (1)	12·29 per cent.
(2)	3·0 " "	(2)	12·44 " "
(3)	3·1 " "	Mean	12·36 " "
Mean	3·03 " "		3·03
		Solids not fat	9·33 " "

The upper portion of the milk, one gallon, was well mixed and a sample showed:

Fat (1)	4·9 per cent.	Total solids (1)	14·01 per cent.
(2)	4·8 " "	(2)	14·02 " "
(3)	5·0 " "	Mean	14·015 " "
Mean	4·9 " "		4·9 " "
		Solids not fat	9·115 " "

This analysis shows that practically the only change on standing is a rise of fat. This, of course, slightly raises the percentage of other solids in the lower portion, since the abstraction of any constituent from a mixture raises the percentage of all the remaining constituents. The upper portion contains, roughly, five parts of fat for every three parts contained in the lower portion. The minimum of fat allowed for genuine milk is three per cent. The increased amount of fat thus procured, in the part of the milk to be used, represents a real gain in feeding the infant. The newer analyses of milk do not confirm the older view that cow's milk contains more fat than human milk,

but rather the reverse. Thus Professor Leeds found, upon analyses of forty-three samples of woman's milk, an average of 4·013 per cent. of fat, while upon analyses of eleven samples of whole market milk the average percentage of fat was only 3·75 per cent. König finds the average of fat in woman's milk to be 3·90 per cent., and in cow's milk 3·66 per cent. Professor Rotch places the average of fat in both cow's and woman's milk at four per cent. As cow's milk has to be more or less diluted before being administered to the infant, the necessity of starting with a preparation that is rich in fat will be apparent. The next step to be taken is to see that all fermentation in the milk is stopped. Cow's milk, as ordinarily procured, must be treated for its biological as well as its chemical properties. The well-known process of sterilization aims to fulfill this object. Partial sterilization, or pasteurization, to the point of killing the germs only, is necessary and desirable. The high and continuous temperature required to destroy spores produces various unfavorable changes in the milk. Practically, all that is required is to submit the milk to sufficient heat to destroy the bacillus of lactic-acid fermentation which causes the souring of milk. This bacillus has been described as of small oval form, occurring singly and in pairs. It is easy, by prolonged and repeated applications of high temperature, to keep milk indefinitely from souring. By reheating once or twice, it can be kept for months without any sign of acid fermentation. Such milk, however, is by no means fit for administration to the infant, as the fat collects in masses and changes have taken place in the albuminoids. The casein is altered, the milk remaining more or less liquid in the stomach, as the action of the stomach acids and of the lactic ferment on the casein of sterilized milk is incomplete. Analyses of excrement show more nitrogen and more fatty acids after feeding with sterilized

milk than with raw milk. Not only is the digestibility of the milk diminished by long heating, but the necessity for it indicates so many bacteria that their excreta, which can not be rendered harmless by heat, may cause poisoning. It has been found that milk well sterilized will, after a certain interval of time, undergo a species of decomposition with an alkaline reaction. Dr. Koplik states that the alkaline fermentation has not been investigated to such an extent that we can with certainty pass upon the deleterious or non-deleterious effects upon infants of the products of this decomposition. It is enough to know that it takes place, and certain alkaloidal elements are very slowly but surely produced. Accordingly, this writer condemns the storage of sterilized milk and its subsequent use after prolonged periods, and I concur in this opinion. Simply sufficient heat must be applied to the milk to keep it sweet until the next supply can be procured. An ordinary double boiler, such as is found in every kitchen, will meet all the requirements of average heating. The Arnold steam cooker may prove more convenient, and Freeman's pasteurizer is handy and efficient. As a rule, fifteen minutes' heating is sufficient with the bottles well plugged with cotton. The addition of a one-per-cent. solution of peroxide of hydrogen is a safe preservative of milk for some hours, when heating is undesirable or not convenient. If more scrupulous care were exercised at the source of the milk supply, and the impurities completely separated by the centrifugal process, in the great majority of cases no means at all for preservation need be employed, and an advance in this direction is urgently needed.

We still have facing us the old and difficult problem of how to act best upon the tough, leathery curds of cow's milk as to make them most acceptable to an infant's weak digestion. Not only are the albuminoids much greater in

amount in cow's milk, but the portion coagulable by acids is greater than the non-coagulable part, while in woman's milk the non-coagulable part much exceeds the coagulable portion. Hence the dilution of cow's milk, while reducing the albuminoids to a proper percentage, does not necessarily render the clot sufficiently soft to be readily digested by the infant. The question whether the size of the curd stands in any relation to the substance used as the diluent has been disputed. It has been taught that by adding gruels of the cereal grains to the milk the clot is mechanically attenuated. Dr. Rotch states, on the contrary, that practically the size of the curd depends simply on the dilution of the albuminoids and not upon the particular menstruum used.

Clinical results, however, point plainly to the utility of diluting with barley water, except in very young infants, and I believe the beneficial effects are, to a certain extent, due to a lessening of the compact character of the clot. In order to test this, the following experiment was made by Dr. Eiloart: Equal parts of milk and barley water were taken, and grm. 0·1 of hydrochloric acid was added to 100 c. c. of the mixture. This strength was employed, as in gastric juice there is grm. 0·2 of hydrochloric acid to 100 c. c. of fluid, which, on dilution by the contents of the stomach, is weakened somewhat, so that grm. 0·1 is a fair estimate for the experiment. Some albumins require 0·2 per cent. hydrochloric acid added to pepsin in artificial digestion to obtain the best results, but casein and vegetable albumin are digested best by 0·1 per cent. of hydrochloric acid.* This experiment showed the casein formed in finely divided clots. Next, equal parts of plain water and cow's milk were taken and grm. 0·1 hydrochloric acid

* Hammarsten. *Lehrbuch der physiologischen Chemie*, 1891.

added to 100 c. c. of the mixture. This showed larger clots than before. A number of repetitions gave similar results, using various coagulating agents when plain water and thin gruels were used as comparative diluents. When rennet alone was used as the coagulating agent, the results were so different from those obtained when hydrochloric acid was used with the rennet that recourse was had to the stomach itself, with results given in the accompanying paper by Dr. Eiloart. The disadvantage in the employment of wheat or barley flour consists in the large proportion of starch contained in these grains, which may be great in very young infants. This starch may be rendered more soluble and easy of assimilation by heat or diastasic action. In many cases the effect of prolonged heating upon barley and wheat flour seems to have a beneficial effect, particularly when there is a tendency to diarrhœa. The good results of the old flour ball, made by prolonged boiling of the wheat flour in a bag, have long been recognized. But the heat so applied does not produce its beneficial effect by chemically changing the starch, but probably from some physical alteration which renders it more effective as a diluent.

The effect of dry heat upon starch is to produce changes into soluble starch, retrodextrin, achroodextrin, and finally a small percentage of dextrose and maltodextrin.* The higher dextrins are more soluble. Starch does not begin to dextrinate until 250° F. is reached, and this temperature should be maintained for several days if there is any quantity to be changed. At between 350° F. and 400° F. dextrination may take place in a few hours. It is evident that such a high temperature can not be maintained by any domestic process. If put into an oven the flour will soon

* Stohmann and Kerl. *Muspratt's Chemie*, Bd. xi, Braunschweig, 1889.

be scorched or burned. An interesting experiment was made by Dr. Eiloart upon barley flour that had been heated for a week in an ordinary double boiler. The water in the under vessel was allowed to boil for a week, with the exception of a few hours at night, the dry flour in the upper vessel being thus exposed to as high a constant temperature as possible under the circumstances. An analysis of the unheated meal taken from the same barrel yielded two thirds more sugar and one quarter more dextrin than the heated meal. The cause of this is that the diastase, whose function it is to convert starch into sugar and dextrin, is partially paralyzed by heat, the ferment undergoing this change at about 175° F. This method of acting upon the starch was accordingly abandoned, and the necessary change effected easily and quickly by means of diastase. Starch treated with diastase is split up quickly into maltose and dextrin, and the longer the action is continued, the higher dextrin will be formed, such as achroodextrin and maltodextrin. After a number of experiments and analyses, Dr. Eiloart devised a receipt for which I am indebted to him, and which has been used at the babies' wards, consisting of a mixture of barley or wheat flour treated with diastase,* the temperature of digestion being regulated by the addition of hot and cold water in proper proportion. The complete description of the process will be found in Dr. Eiloart's paper.

This food can be easily and cheaply prepared in any household, and while the starch is changed to more soluble forms, there is not an excess of sugar. Herein it is superior to the various Liebig's foods. The nutritive value of the albuminoids is likewise not lost sight of.

Either barley, wheat, or oatmeal may be thus treated, the principal difference being the varying proportions of

* Maltine was the preparation here yielding the diastase.

fat contained in these grains. According to Dietrich and König, the percentage of fat is as follows: Barley, 2·09; wheat, 1·55, and oats, 6·09. This may be borne in mind in prescribing for diarrhœas and the various forms of indigestion.

The effect of malt upon milk is to favor its digestion and assimilation. Garup Besanez, a German authority on malt, has found a ferment in the germinated seed of vetches, hemp, flax, and barley, which very energetically converts starches into grape sugar, and albuminous substances (fibrin) into peptones. It was afterward found that diastase has no action upon albuminoids, but peptase—which is generated in germinating grain at the same time and under the same conditions as diastase, and practically they can not be separated—acts upon proteids slowly at low temperatures. This substance is an analogue of the vegetable proteolytic ferments found in pineapple juice and the papaw plant.

The actual results obtained from the use of food thus prepared in the babies' wards have been good, considering the class of cases treated. During May, June, and early July thirty-seven infants suffering from various degrees of gastro-intestinal irritation and inflammation, and from one to ten months old, were thus fed. Seventeen increased slightly in weight after a week or so, sixteen lost a little in weight, and four remained stationary. As is well known, the loss of weight in gastro-intestinal affections during infancy is usually well marked, and is exceptionally rapid in hospital and institution infants. So extremely susceptible are young infants to hospitalism that they invariably lose weight after a certain interval of time, and will die of inanition under any system of artificial feeding unless removed in season. A baby admitted May 26th, one month old, having had convulsions from gastro-intestinal irritation,

exemplifies this fact. The weighings are registered as follows: On admission, six pounds one ounce; May 30th, six pounds four ounces; June 2d, six pounds six ounces; June 6th, six pounds eight ounces; June 9th, six pounds five ounces; June 13th, six pounds two ounces; June 16th, five pounds and ten ounces; discharged. The gastro-intestinal irritation subsided and the baby did well on its food, but at the end of two weeks it began to show the effects of hospitalism, although there was no vomiting or other sign of indigestion. When sterilized milk, diluted to the proper point with water, limewater, or plain barley water, has been used, there is almost invariably a steady and slow loss of weight from the first, so that the change so often noted upon malting the preparation can not fail to be gratifying. Dr. Judson C. Smith, who is the district visitor for the hospital, seeing a certain number of the patients after they have been discharged, tells me he has used the extract of malt to peptonize milk about a year, both for infants and adults, with very satisfactory results. Babies from four months to one year old, when losing weight on other methods of feeding, have usually gained flesh and improved in every way on milk prepared with malt. One tablespoonful of malt is added to a pint of milk, which is heated from twenty to thirty minutes and then brought to the boiling point. The milk is then diluted with water according to the age of the infant.

A FOOD FOR INFANTS,

WITH EXPERIMENTS, CHEMICAL AND PHYSIOLOGICAL.*

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The experiments here described were intended to throw light upon two problems. The first was the formation from cow's milk of a curd resembling in fineness that from woman's milk. The importance of this seems evident,† and Uffelmann‡ has shown that in artificial digestion the proportion of peptone formed is greatest when the curd is loosest. He recommends mixing cow's milk with three fourths its volume of 0·2 per cent. hydrochloric acid in order to make the casein like that of human milk.

Munk,# having tried Scherff's process of sterilization (heating to 100° C. under a pressure of three atmospheres), states that milk so treated clots *in the stomach itself* in flocks like woman's milk, not in compact masses like ordinary cow's milk.

* Read before the Section in Pædiatrics of the First Pan-American Medical Congress.

† Ellenberger and Hofmeister, however, object to the fine curd of sterilized milk, because it may pass too quickly through the system and thus escape complete digestion (*Molkerei Zeitung*, 1892, 6)

‡ Pflüger's *Archiv*, 29, 399.

Deutsche med. Woch., 1881, No. 36.

It seems unlikely, however, that these methods will come into general use, and the following work has been confined to testing diluents which are everywhere available.

The result of a preliminary investigation was surprising, for it appeared that the fineness of the curd depended more on the curdling agent than on the diluent mixed with the milk. Thus, with rennet, mixture A curdled finer than mixture B, while with hydrochloric acid, one per cent., mixture B curdled finer than mixture A.*

Hence the test-tube experiments, which have constantly been quoted to show the effect of various diluents, must be abandoned, and the infant's stomach itself must be consulted to decide what mixture will curdle finest in that stomach. Accordingly, the mixtures to be tested were administered to infants, and after a short interval withdrawn by means of the stomach pump. I am indebted to Dr. Chapin for the opportunity of carrying out these tests in the babies' wards of this hospital.

In the following table I have used figures to indicate degrees of fineness of clot, calling the finest curd 1 :

The figure 4, indicating the very coarse clot sometimes obtained with hydrochloric acid (0·1 per cent.), is absent from the record of stomach clots, although the percentage of acid in the stomach, calculated as hydrochloric, sometimes rises almost to 0·1 per cent.

The chief conclusion to be drawn from the stomach experiments is that the coarseness of curd increases with the percentage of acid. Thus the finest curd (called 1), which was only once obtained, occurred when the acidity was 0·0467

* Mixture A was equal parts of milk and water; mixture B was equal parts of milk and barley water. With a mixture of hydrochloric acid and rennet the result was the same as with the acid alone. In every case the volume curdled was 100 c. c.; very small quantities fail to show the differences in the curd.

TABLE I.—*Showing Fineness of Clot and Acidity of Stomach Contents after feeding with Milk and Various Diluents. Fresh Milk was used except where Sterilized is mentioned.*

Throughout this work the regularly prescribed malt preparations were used as the source of the diastase; + means a small dose, ++ a full dose.

Experiment No.	Date.	Name.	Age.	Health.	Taken.						Time before pumping.	Quantity pumped.	Fineness of clot.	Acidity calculated as HCl.	
					Milk.	Water.	Barley water.	Wheat gruel.	Wheat, Recipe II.	Diastase.				Total.	Per cent. of quantity pumped.
			M'ths.								Min'tes.	C. c.			
1	Feb. 15	George Carlson.....	8	Good (adenitis).....	50	50	..	..	..	..	1	117	3	·050	·0427
2	" 15	S. Morris.....	2	Bad (syphilis).....	50	50	..	..	..	..	1	12	3	·0109	·09
3	" 15	Annie Riker.....	6	Medium (inanition)....	50	..	50	..	..	..	1	109	2	·047	·0438
4	Mar. 4	Ed. Scores.....	1½	Good (eczema).....	100	..	..	..	..	+	1	15	1	....	....
5	" 4	S. Morris.....	2½	Fair (syphilis).....	30	..	30	..	..	..	1	27	2	....	...
6	Apr. 25	Ab. Sayres.....	2½	Good (cured).....	st'd 100	100	..	..	..	+	10	124	3	·137	·0905
7	" 25	Henry Hasbrook....	6½	" "	st'd 100	100	..	..	..	..	10	140	1	·065	·0467
8	" 29	Ab. Sayres.....	..	.....	st'd 100	100	..	..	..	..	10	108	3	·093	·086
9	" 29	Henry Hasbrook....	..	.....	st'd 100	100	..	..	..	+	10	97	2	·061	·063
10	May 3	Ab. Sayres.....	..	.....	70	70	..	..	..	++	20	28	2	·017	·060
11	" 3	Walter Grandman..	6	Good (cured).....	100	100	..	..	..	..	15	9·5	2	·0087	·092
12	" 8	Ab. Sayres.....	..	.....	51	51	..	..	..	..	15	86	3	·063	·073
13	" 8	Walter Grandman..	..	.....	60	60	..	..	..	++	15	44	3	·0289	·066
14	" 8	Frances Collins.....	1½	Marasmus.....	35	35	..	..	..	++	20	65	3	·052	·083
15	" 8	Louisa Bechl.....	8	Good (gastro-enteritis).	54	54	..	..	..	..	20	59	3	·031	·053
16	" 19	Joseph Kelo.....	3	Good (phimosis).....	71	..	..	..	71	..	2	70·5	3	·046	·066
17	" 19	Joseph Lobe.....	2½	Fair (erythema).....	65	..	65	..	..	..	2	65	2	·031	·047
18	" 19	Frances McIntyre...	3	.....	45	..	45	..	..	..	3	67	2	·046	·069
19	" 22	Frances McIntyre...	..	.....	85	..	..	..	85	..	2	60	1	....	....
20	" 22	Joseph Lobe.....	..	.....	100	..	..	..	100	..	1	135	2	....	....
21	" 22	Mary Bailey.....	3	Marasmus.....	75	..	..	75	..	..	14	59	2	....	....
22	" 22	Joseph Kelo.....	..	.....	75	..	..	75	..	..	4	7	3	....	....

per cent.; the curd next in fineness occurred in six cases in which the mean acidity was 0·062 per cent.; whereas for curd 3 (rather coarse) the acidity averaged 0·072 per cent. (mean of nine cases).

So far we have left out of account the diluent used. If we arrange the results so as to show the number of times a given diluent produced a curd of the second or third degree of fineness, we find that water gave clot 2 once, clot 3 four times; barley water gave clot 2 three times; diastase, with or without cereals, gave clot 2 twice, clot 3 four times.

So far the results proclaim barley water to produce the finest and water the coarsest curd. But when we take into account the acidity in the different cases, we find it to average in the three barley-water experiments only 0·053 per cent., while in the four water experiments it is 0·077, and in the case of the diastase preparations, which yielded curds almost as coarse as the water mixtures, the acidity is nearly as high—viz., 0·071 (average of the six cases).

The good results apparently due to the barley water may, therefore, be due in reality to a low percentage of acid. On the other hand, further experiments may show that barley water itself causes the low percentage of acid.

The influence of the concentration of the curdling agent is well seen in the following experiment, made with an adult: A mixture of 500 c. c. milk with 500 c. c. water at blood-heat was taken. Two minutes afterward 360 c. c. were pumped out from the stomach; six minutes later 400 c. c. more were removed; eight minutes later the rest was removed.

The first portion was curdled so fine that close examination was needed to see that it was not homogeneous. The second portion was fine, but coarser than before. The third portion consisted of yellow liquid with some clots—quite coarse; the gastric juice was no longer diluted by excess of milk.

Experiments with Cereals.—Whatever be the part played by barley water in the stomach, it has made good a place in infant feeding, which indicates that benefit is derived from its use. But it seems probable that any such benefit is largely neutralized by the great proportion of starch which all cereals contain and which the infant economy is ill adapted to digest.

It is true that infants' foods may be bought in which the starch has been dextrinized by heat; but these are expensive. The object was then to devise a household process for preparing at a minimum cost, and with materials everywhere available, a digestible food containing with the albuminoid constituents of the grain carbohydrates in a soluble form, and but little of the insoluble starch. At the same time excess of sugar was to be avoided. This necessitated the conversion of the starch into dextrin, or into dextrin with a moderate proportion of maltose. Attempts to dextrinize the starch by heat showed that this method is not adapted for household use. Barley cakes baked many hours yielded only 23·3 per cent. of soluble matter. Rusks ("*Zwieback*") as bought were further baked, but only 16 per cent. could be made soluble. To facilitate the dextrinization by providing an acid, barley cakes were made with buttermilk and well baked, but the soluble matter was then only 20·07 per cent. Rusks moistened with buttermilk and baked at 120° C. yielded 18·88 per cent. of soluble matter.

These results necessitated a resort to diastase as the converting agent. O'Sullivan has shown that maltose and dextrin are the only products of the action of diastase on starch, and that the proportion of maltose to dextrin depends on the temperature. This proportion may be kept down to about eighteen per cent. by employing a tem perature just below that which destroys the diastase and

by stopping the action before the diastase converts the dextrin first formed into maltose. To adjust the temperature, hot and cold water were mixed in varying proportions. The temperature of the hot water was the highest which can be attained in the inner vessel of an ordinary double boiler of tin or enameled iron when the water in the outer vessel is kept boiling; this temperature does not vary much with the size of the boiler and is about 91° C.

The diastase was allowed to act on gruels made with starch, with wheat flour, with barley meal, and with oatmeal. The line of action, the quantity of water, and the temperature (proportion of hot to cold water) were varied, and more than twenty analyses were made to determine the proportion of soluble matter and of maltose formed in each case. As the result of these experiments a most simple process was arrived at, by which in any kitchen a cereal food may be made containing three fourths of the solid matter in a soluble form and having more or less sugar (maltose) as desired.

For a food containing about one third of the solid matter in the form of maltose, the following recipe may be used:

Recipe I.—*Materials.*—Wheat flour or barley meal, two ounces (two tablespoonfuls heaped as high as possible); water, fifty-six ounces (a quart and three quarters); extract of malt, half a teaspoonful or a small teaspoonful.

Process.—With thirty ounces (a scant quart) of the water make the flour into a gruel, boiling ten minutes in a double boiler. Take out the inner vessel and add the rest of the water cold, the malt extract being dissolved in the last few ounces added. Let it stand fifteen minutes. Put back the inner vessel and heat again in the double boiler fifteen minutes. Strain through a coffee strainer of wire gauze.

If for any reason it is desirable, and in cases of diarrhœa to give a smaller proportion of maltose, the follow-

ing recipe is used, and we get a food containing only one fourth of the solid matter in the form of maltose:

Recipe II.—*Materials* as in Recipe I. Proceed as before, but reserve only one pint of the water for adding cold. After adding the cold water with the malt extract dissolved in the last few ounces of it, let it stand only three minutes instead of fifteen minutes. Then heat ten minutes in a double boiler and strain.

To make the gruel well and quickly, beat the flour with very little water. A little beating with little water is better than much beating with much water. Beat smooth, therefore, while the paste is still almost a dough; then add cold water to make a thin paste, and to this add the rest of the first part of the water boiling hot, with stirring. If these directions are followed, very few lumps will remain on the strainer; in fact, only about five per cent. of the meal need be lost in this way. The water in the outer vessel of the double boiler must be kept boiling throughout. Whichever recipe is followed, the food should be taken mixed with milk.

Digestion Tests.—Cæteris paribus, the more of a food is dissolved in the stomach, the more digestible is that food said to be. Therefore if we find in the stomach contents, after giving milk with the malted food, a larger proportion of soluble matter than when milk is given with unmalted food (due allowance being made for the larger proportion of soluble matter in the malted food itself), then we may say that the malted mixture is the more digestible of the two. In order to test this, experiments were made with three infants and the following results were obtained:

Ratio of Soluble to Total Matter in Stomach Contents:

	With Malted Food.	With Unmalted.
Subject 1.....	0·65	0·58
" 2.....	0·74	0·61
" 3.....	0·58	0·64

The difference is appreciable (later results indicate that this was due to the short time allowed for digestion, which never exceeded a few minutes in the above cases). Experiments were next tried without the admixture of milk. A comparison was next made between the two foods without admixture of milk. The process now followed was this: The stomach of a healthy man was washed clean with lukewarm water—*i. e.*, the washing was continued till the water from the stomach ran perfectly clear. Then a definite measure of gruel containing a known weight of solid food was drunk in five equal draughts with an interval of a minute between each draught. After a certain time the stomach was again completely washed; the washings were made to a given volume. The total solid matter and the dissolved matter were determined; the difference gives the matter undissolved. Experiments were made with three men, all free from any disorder of the stomach. The food prepared with diastase was given one day and the plain gruel the next. Although the amount of either food disappearing in a given time varied considerably, the results were sufficiently concordant to decide the question at issue.

Experiments 1 and 2, which were made without previous washing of the stomach (no food having been taken since the night before), agree fairly well with the others, showing that the digestive process is not rendered abnormal by previous washing. In the case of Subject No. 1 the amount found in the stomach was constantly greater when the diastase was omitted; the percentage of food taken which was left in the stomach after forty minutes being, without diastase, 52·02; with diastase, 29·2. This means that of a hundred parts of food taken, 100 — 52·02 or 47·92 were absorbed in the one case and 100 — 29·2 or 70·8 in the other; so that with the diastase nearly half as much

TABLE II.—*Showing Proportion of Food found in Stomach after Various Periods of Digestion.*

A dash (—) under diastase indicates that none was given. A + indicates that the diastasic extract was used in the proportion given in the receipe.

Experiment No.	Date, July.	Food taken.			Found in stomach after time named.				Time, minutes.	
		Volume, cubic centimetres.	Weight, grammes.	Diastase.	Total solids.	Undissolved solids.	Per cent. of food taken.			
							Total solids.	Undissolved solids.		
1	8	500	11·76	—	5·48	·62	46·6	5·3	40	Subject No. 1. Recipe No. II.
2	11	1,000	38·6	+	14·35	1·81	37·0	4·7	40	
3	12	1,000	30·24	—	13·2	2·39	43·7	7·4	40	
4	13	1,000	30·00	+	8·96	·67	29·8	2·2	40	
5	15	1,000	25·00	—	13·94	2·09	65·76	8·36	40	
6	15	1,000	25·00	—	10·5	1·3	42·0	5·2	24	Subject No. 2.
7	17	1,000	25·00	+	8·82	·56	35·28	2·24	22	
8	17	1,000	25·00	+	6·97	·69	27·88	2·76	24	
9	18	1,000	25·00	—	7·75	1·83	31·00	7·32	23	
10	19	1,000	24·4	—	7·6	1·7	31·1	7·0	23	
11	19	1,000	24·4	—	8·19	2·58	33·5	10·5	24	
12	20	1,000	24·4	+	11·44	1·08	46·7	4·43	24	
13	22	1,000	25·0	—	2·93	·62	9·72	2·48	40	Subject No. 3.
14	23	1,000	25·0	+	1·60	·14	6·4	·56	40	
15	25	1,000	25·0	—	7·06	1·00	28·24	4·00	40	
16	20	1,000	25·0	+	6·27	2·23	25·08	8·92	25	
17	22	1,000	25·0	—	9·48	2·55	37·92	10·2	25	
18	24	1,000	25·0	+	4·97	·66	19·88	2·64	30	
19	25	1,000	25·0	—	6·84	1·39	27·36	5·56	30	

again was absorbed as without it. Of the solid matter found in the stomach, more than twice as much was found to be undissolved when the diastase was omitted as when it was used.

With Subject No. 2 a shorter time (twenty-four minutes) was given for digestion and no marked difference appeared between the two foods; but when the time of digestion was extended to forty minutes the malted food again asserted its superiority, the amount of this unabsorbed by the stomach being only one third the amount of the plain food unabsorbed. In the case of Subject No. 3 the difference in favor of the malted food was made manifest in twenty-five minutes. In every case, therefore, digestion was more rapid with the malted than with the unmalted food. Thus the physiological evidence confirms the chemical evidence in favor of the food prescribed. Finally, clinical experiments with the soluble food, made according to Recipe No. 1, have given as good results as any system of feeding employed at the babies' wards of the Post-graduate Hospital, as detailed in the accompanying paper by Dr. Chapin. It is intended to employ the method of quantitative stomach washing in other cases, as it seems adapted for testing foods and digestive ferments in general.

July 9, 1893.

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