Observations on Milk Coagulation and Digestion

By **FRANKLIN W. WHITE, M. D.**
Boston, Mass.

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IN EXCHANGE

F. W. Putnam

Observations on Milk Coagulation and Digestion

THE proteid element in cow's milk is the portion most likely to cause trouble in infants and other persons whose digestive powers are feeble. Various methods have been used to render it more digestible, such as diluting or peptonizing the milk or the addition of mucilaginous substances to render the milk curd finer and softer, that it may be more readily broken up, and expose a larger surface to the action of the digestive fluids, and also render the passage through the pylorus more easy.

This last method is the one we shall consider, and usually consists of diluting the milk with decoctions of cereals, such as oats, barley or wheat.† Our observations have been made to determine: First, whether or not these cereal decoctions render the milk curd more fine and soft than a simple dilution with water. Second, whether one cereal is better than another for this purpose. Third, whether or not the property of yielding a fine curd is wholly due to the starch in solution, and if so, what per cent. of starch is desirable? Fourth, to test the value of certain modifications of the methods which have been recommended, Fifth, to determine the effect of lime water and albumen water upon the casein curd.

The method is an old one and the clinicians, especially the pediatricists, have always been more

†These are the cereals used in Eskay's Albumenized Food.

interested in the results than the chemists, and have written more about it.

Huebner, Jacobi, Starr and others believe that cereal decoctions mixed with milk have the power of getting between the particles of curd mechanically during coagulation, and preventing their running together and forming a large compact mass. Chapin, after careful experiments in test tubes and on dogs, came to the same conclusion. He believes that the particles of cellulose, the ground up cell-wall of the cereals suspended in the fluid, have also an important mechanical action on the coagulum.

Chapin, Starr and J. L. Smith recommend that the starch should be dextrinized by the action of diastase, as this makes the starch more digestible and still preserves, or even increases, according to Chapin, its action on the curd. On the other hand, Rotch and Harrington, from experiments in test tubes, conclude that the size of the curd depends on the degree of the dilution of the milk rather than on any special property of the diluent; that barley water shows only a fractional difference from water, and that until more is known about the matter plain water is the most practical and efficient diluent. Holt and Biedert also question whether anything more is accomplished by dilution with cereal gruels than with water. The practical importance of this method of feeding infants and sick persons, and the difference in opinion as to its value render it a fit subject for further study. The following experiments were begun at the suggestion of **Dr. T. M. Rotch**, of Boston :

The coagulation of milk was first studied outside of the body in test tubes, and the results confirmed later by animal experiments. In the experiments

in test tubes, the conditions which exist in the stomach were simulated as far as possible. The milk was kept at body temperature and was coagulated by rennet or dilute hydrochloric acid, or a mixture of the two, the amount of acid present being from 0.2 to 0.3 per cent, which is the acidity of the normal stomach of adults. The milk was gently agitated during the formation of the curd by inverting the test tube slowly a half-dozen times. The milk was mixed with an equal part of the diluent and 50 Cc. of the mixture used in each case. As the coagulation of casein by rennet is somewhat different from its precipitation by dilute acids, a double series of observations were made. To one specimen of milk mixture, 2 or 3 Cc. of an active solution of rennet were added. And to another, 1 to 1½ Cc. of a 10 per cent. solution of HCl; an excess of HCl was avoided, in order not to redissolve the precipitated casein. The coagulation always took place completely within a half minute with both acid and rennet. After noting the size and character of the curd, it was usually shaken moderately for a moment to determine whether it was soft and easily broken up, or tough and tenacious. The **cereal decoctions** were made from **barley, oats, rice and wheat**, partly from the grains themselves and partly from cereal flours; two tablespoons of cereal grains, soaked over night in water, were boiled for several hours in a quart of water, keeping the quantity up to a quart by the addition of water, and strained through coarse muslin; or two tablespoons of cereal flours were boiled for fifteen or twenty minutes in a quart of water. The decoctions obtained by these two methods are practically the same in character and action, and after the first few experiments the

cereal flours were used entirely, for the sake of convenience. The decoctions were freshly prepared for each series of observations, and a portion was dextrinized for from fifteen to twenty minutes with Taka-diastrase (0.1 Gm. in 200 Cc.) before mixture with the milk.

An analysis of four specimens of barley water gave an average of 1.5 per cent. of starch. A complete analysis of one specimen of barley water gave the following results :

Starch	1.56
Fat	0.05
Proteid	0.25
Salts	0.03
Water	98.11
	<hr/>
	100.00

This analysis shows that the starch is the only element of importance in the solution, the others being too small in amount to have any effect. In our experiments, the milk diluted with 1 ½ per cent. starch solution contained approximately seven-tenths per cent. In the first series of experiments, a comparison was made with milk diluted with equal parts of : (1) Water ; (2) Barley water ; (3) Barley flour water ; (4) Barley flour water dextrinized.

Coagulation was produced by : (A) Rennet ; (B) HCl ; (C) a mixture of rennet and HCl.

The second series was a repetition of the first. In the third series a comparison was made between milk diluted with equal parts of the following :

(1) Water	(6) Barley water dextrinized
(2) Barley water	(7) Oat “ “
(3) Oatmeal “	(8) Rice “ “
(4) Rice “	(9) Wheat “ “
(5) Wheat “	

The fourth series is a repetition of the third series.

The results were as follows: **Milk and cereal water** in the strength used always *yielded much finer curds than milk and water*.^{*} The curds in the first place being **soft, firm and flocculent**; and in the second, **large, tough and cheesy**. There was no qualitative difference in the action of HCl or rennet as a precipitant. There was no difference in the action of cereal waters made from the grains or from flours; there was no practical difference in the action of different kinds of gruels when made in the same strength.

The dextrinized gruels in three instances gave the same results as the plain gruels; in seventeen instances yielded a **coarser and tougher** curd, in four of the latter **having no more action than water**, and in thirteen being intermediate between water and plain gruel. This variation is due, I think, to the different degrees of action of diastase on the starch, **the more complete the malting, the less the effect upon the curd**. The results from test tube experiments were briefly—that *cereal water was much better than water for our purpose*, and dextrinized cereal water intermediate between the two. The next step was to test these results in the animal stomach. Cats and dogs were used for the experiments, being fed with the same mixtures as were used in the test tube experiments, then killed one-half hour later and the stomach contents removed and examined. The results were as follows: **The difference between the action of barley water and water as diluents was more striking, if anything, in the stomach**

^{*}See cut on Page 12.

than in test tubes.† Where water was used, the casein was, for the most part, gathered in one or more solid rounded masses surrounded by rather clear whey. Where barley water was used, it was in the form of soft flakes, evenly distributed. **Where dextrinized barley water was used, the curd was much coarser and tougher than with plain barley water, and approached closely the curd yielded by milk and water.**

STOMACH CONTENTS.

MILK AND WATER.

Several of the milk and barley water mixtures were heated to 167°F. for one-half hour, as is ordi-

†See cut above (which accompanied Dr. White's original article).

narily done in the pasteurizing of milk, to determine the effect. It was found that there was little difference between heated and unheated milk, *but, if anything, the action upon the curd was slightly improved by heating the milk and barley water together in this way.* Now, that we have clearly proved the action of barley water in reducing the size and tenacity of the milk curd, we must ask for an explanation of this effect.

I believe that it is **mainly, if not wholly, due to the starch that is in solution; starch**, in common with all colloidal substances, *possesses the physical property of forming fine emulsions*, which is analogous to its action in getting between the particles of casein curd and preventing their uniting into a firm mass. This will explain also the variable action of the dextrinized barley water. The starch was rapidly converted under the influence of an active ferment to dextrin and then to crystalline **maltose, which presumably had no effect on the curd, and the greater the degree of conversion in any specimen, the less its effect on the casein.** This view was confirmed by the following experiment:

A specimen of 300 Cc. barley water was dextrinized with 0.2 Gm. taka-diastase; samples were removed at the start and at intervals of fifteen minutes for an hour, and mixed with an equal amount of milk. The milk was coagulated immediately after the mixture, one portion with HCl and one portion with rennet.

The milk mixture containing barley water, which had been dextrinized for fifteen minutes, yielded a decidedly coarser curd than milk and plain barley water. Those containing barley water, which had been dextrinized for thirty min-

utes or longer, yielded a curd of the same character as produced in milk and water. In short, instead of preserving or improving the action of barley water by converting the starch, as claimed by Chapin, we find that **its action is speedily lost if the ferment is an active one.** This experiment also disposes of the idea that *cellulose in suspension or calcium salts in solution* derived from barley have any important action on the curd, for the properties of the fluid were lost when the starch was removed; even though cellulose and salts were left. It was also found that a *boiled and strained solution of corn starch*, in which there is relatively little cellulose, gave the same result in milk mixtures as a barley water containing an equal per cent. of starch.

Experiments showed that from $\frac{7}{10}$ to $1\frac{5}{10}$ per cent. of starch was best for practical results; less than $\frac{7}{10}$ gives much coarser curds, and this explains the variety of opinions which have been held of the value of barley water as a diluent of milk. Those who found it without effect, used too dilute a preparation.*

Albumen water mixed with milk, for the purpose of preventing large tough curds, is not practicable, for two reasons: First, it has no effect on the curd in 1 per cent. or $\frac{3}{4}$ per cent. solutions, which are the strongest that can be used without giving too much proteid. Second, the mixture could not be pasteurized without coagulating a considerable amount of proteid.

A few additional observations were made on the effect of adding lime water to milk. The experi-

*The amount of starch in Eskay's Albumenized Food, when prepared for administration, is from 1 to $1\frac{1}{2}$ per cent., which is within the limits giving the best results according to Doctor White.

ments showed that the *addition of lime water to milk simply prevents the action of rennet until the alkali is neutralized by the secretion of HCl in the stomach, but does not affect the character of the curd which is then formed.* Probably the only effect of the small amount of lime water, usually added to milk in infant feeding, is to neutralize some of the lactic acid which may be developed in it.

The practical importance of using cereal decoctions as diluents of milk is so obvious that I shall do no more than mention it. Milk is one of the most important of food-stuffs; it is the exclusive food for infants, the basis of the diet of older children, and is commonly used by adults where digestion is impaired from whatever cause, as in fevers, diseases of the stomach and intestines, and nephritis, and any method which can increase its digestibility has a wide practical application. Surely, *every physician who has to feed an infant upon cow's milk with its 3 per cent. of casein in place of human milk with ½ perc ent. of casein, will fully appreciate any method which will render the coagulum more digestible.* The conclusions from my observations may be summarized as follows:

1. *Dilution of milk with cereal decoctions of proper strength renders the casein curd much more fine, soft and digestible than simple dilution with water.** There is no difference in the action of various cereals, such as barley, oats, rice or wheat.

2. *The above property is due mainly, if not wholly, to the starch in solution, the most desirable*

* When the cow's milk is modified by the addition of Eskay's Albumenized Food the formation of tough curds is entirely prevented. See cut at end of this article, page 12.

amount of starch in the milk mixture for practical use is approximately three-fourths per cent.

3. *Diastase, by converting the starch to dextrine and maltose, promptly lessens and removes the action of cereal waters upon casein.* Its addition, therefore, is not a practical measure when the action upon the curd is desired.

4. *Albumen water has no practical value as a diluent of milk.*

5. *Lime water added to milk has no more effect than water upon the character of the curd produced in the animal stomach.*

GASTRIC CONTENTS OF A CHILD FED UPON COW'S MILK
MODIFIED BY ESKAY'S ALBUMENIZED FOOD SIPHONED
OFF ONE HOUR AFTER TAKING THE FOOD.
NOTE SMOOTH FLOCCULENT APPEARANCE.

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