HOMOGENIZED MILK: ITS POSSIBLE APPLICATIONS TO INFANT FEEDING.*

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HOMOGENIZATION of liquids of different densities consists in reducing the constituent elements into such a physical condition that they will no longer separate, but will maintain a permanent and even composition throughout the mixture.

Briefly stated, this result is brought about by a powerful pump which forces the mixture through a finely ground agate valve against great pressure. After its passage, the mixture is perfectly homogeneous, and in the case of milk, or mixtures of milk and oils, the fat globules are crushed, torn and pulverized and so incorporated with the other elements of the milk, that they can no longer rise by action of gravity, separate after long standing nor agglutinate.

The mechanical device by which this result is made possible is the invention of M. A. Gaulin of Paris. His first machine was brought out in 1899. With this the fluid elements were forced through very fine capillary tubes, but the practical results were not perfect, owing to the fact that many of the fat globules passed through the smallest possible capillary tubes without alteration. M. Lindet, of l'Institut Agronomique, who had interested himself in Mr. Gaulin's invention, demonstrated that the ascending force of fat globules were proportionate to the cube of their radii, and that the principle of stabilization of milk consisted in reducing these radii to a dimension as near as possible to zero. The diameter of butter fat globules varies from 1/100 to 1/1000 of a millimeter, whereas the smallest holes that can be bored in a metallic surface is about 1/10 of a millimeter. This led M. Gaulin to adopt an entirely new method of carrying out his original idea, and in 1902, he announced his invention of a device which subjected the fat globules to great pressure between two surfaces, exactly adjusted to each other, but sufficiently elastic to permit the passage of the most minutely divided particles.

The essential patent in this homogenizing machine is an agate valve, so finely ground that it will leak only under great pressure, and held in its bed by a variable tension spring, which is regulated by a fly wheel with a screw end. The mixture is pumped against a pressure which may vary up to 500 kilos. The pumps vary in capacity from 50 to 2000 litres per hour; according to the size.

It is not my intention to enumerate in detail the commercial applications of this process, which has been extensively used on the continent and in England and to a considerable extent in this country. The chemical composition of the milk is in no wise affected, but in cases of milk

and cream mixtures, the physical condition is so changed that the fat can no longer be separated by the usual cream separators. In making the Babcock fat test more acids must be used and centrifugal action continued for a longer time.

Homogenization improves decidedly the taste of the milk or cream, particularly that of pasteurized milk. As the process prevents the separation of the fat, homogenized creams can be readily pasteurized. When commercial milk is to be transported long distances in warm weather, and its temperature allowed to rise from lack of proper refrigeration, the continual jolting to which it is subjected causes the cream to be churned into butter fat, and it is impossible to reincorporate it into the milk in its original form. The same disturbance of emulsion may, under similar conditions, happen to milk modifications. We are all familiar with the greasy surface seen in summer in the bottle of milk brought to the clinic by the mother who lives at a distance, so that a considerable quantity of fat is often taken into the baby's stomach in large indigestible globules.

The application of homogenization to ordinary whole milk or to any kind of a milk modification, will overcome this defect; and theoretically it would seem as if it would yield a much more digestible mixture. This is one of the points I hope we shall be able to determine in the series of cases I have planned.

Variot, in Paris, has used an homogenized milk in the "Goutte de lait" de Belleville. He claims it is taken as successfully as breast milk and has never seen cases of infantile scorbutus nor rickets which could be attributed to its use. Chevalier demonstrated by chemical analyses that the constituents of homogenized milk are more completely absorbed than those of simple sterilized milk. The more finely divided the food, the greater is its accessibility to the digestive fluids, and the greater its assimilation.

It is interesting to note also that when rennin is added to homogenized milk, the curd which results is a homogeneous flaky paste, resembling bling closely the curd of human milk.

The process of homogenization has a beneficial effect upon its keeping qualities. An official in the laboratory of M. Gaulin is authority for the statement that milk sterilized and homogenized has been shipped by various methods of transportation for more than 14 1/2 months, and at the end of that time has been found "as good as fresh milk," without the application of ice or addition of preservatives. This fact, if verified, might have an important and practical effect in the shipment of modified milk to distant points. It may be found that one or two shipments a week is safe and practical. If this is so, it would mean a great saving in expense to the consumer, and would facilitate the distribution of prepared mixtures to distant points.

Recently, while discussing various feeding problems with Mr. F. C. Howe of the Walker Gordon Company, I first learned of this inven-

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tion of M. Gaulin. The idea of utilizing it to improve the quality of ordinary milk modifications occurred to us at that time, and it required very little imagination to foresee a possible field for investigation into infant foods which may open many new lines of study. Through the kindness of Mr. Walker, and the coöperation of Mr. Howe, we were able to secure temporarily for experimental purposes one of the homogenizing machines and install it in the laboratory, where it could be run by the power plant of the refrigerating apparatus.

The most interesting application of this principle of homogenization is in connection with the fat constituent of milk modifications, especially in cases of so-called "fat intolerance." These feeding cases are, perhaps, the most difficult ones with which the pediatricist has to deal. Their general characteristics have been so well and so recently described before this society by Dr. Dunn, that it is hardly necessary to discuss them in detail tonight. Briefly stated, one recognizes a class of feeding cases in which the fat of cow's milk, if given in too large percentages, leads to a digestive crisis of a serious nature. The restoration of the infant's tolerance for fat then becomes a very slow and gradual process. During this period the nutrition suffers severely. There are, of course, all degrees of intolerance. The milder cases may generally be corrected and controlled by careful feeding. The severe cases often resist our best efforts and pursue an interrupted downward course. Certain of these babies are capable of digesting high percentages of carbohydrates and proteins so that the nutrition of the body can be maintained, but others are unfavorably affected by such an unbalanced ration. Without recourse to breast milk, they cannot be made to thrive.

The fact that the great majority of cases of fat intolerance occur in artificially fed infants, and the further observation that, in the first year at least, they generally respond favorably to breast-milk, raises the interesting question as to whether it is fat *per se* which causes the familiar symptom-complex or simply the peculiar qualities or reaction to the fat of cow's milk. Generally speaking, breast milk contains a much higher percentage of fat than that which has been given in the milk formula, and yet, under its use, the symptoms gradually disappear, and metabolism is restored to its normal basis.

These considerations have led to more or less experimentation with vegetable oil, and fats of other animals, such as lard, and with cod liver oil. But we have now an opportunity to combine such fats and oils with other milk ingredients in a practically perfect and permanent emulsion, so that we may reasonably expect a totally different result from their use.

If, as a matter of experiment, one can show that olive oil, for instance, is readily digested and assimilated when homogenized with skim-milk, in these cases of intolerance to cow's milk

fat, one can then seek by more detailed experiments, of a more exact and scientific method, to find out what element or elements of cow's milk fat is the source of the toxic substances which seem to be formed in the processes of digestion.

One of the most striking facts which recent metabolism experiments in infants has shown is the interrelation of the various ingredients of milk in normal metabolism. A disturbance in the digestion of an element frequently influences the metabolism of the other elements, and the end result, which we see in the vomiting, diarrhea, abnormal stools, malnutrition and toxemia, represent a very complex series of antecedent causes.

Now, if we can separate in a pure state and recombine into a homogeneous mixture the necessary food elements for an infant, we have advanced to an interesting stage of experimentation to determine some of the possible primary causes which start up the train of symptoms leading to the digestive explosions so often seen in the artificially fed infants.

It is possible, for instance, by this process of homogenization to combine an almost pure olein, or palmitin, or stearin with fat-free skim milk, and so eliminate almost entirely the influence of the various fats of cow's milk. By using a chemically pure precipitated casein, we can combine pure casein with pure oils and pure sugars of different varieties, adding artificially prepared mineral matter in varying proportions. Such mixtures, homogenized, may be found to be of use in exact metabolism experiments, although they would be too expensive and complicated for practical feeding.

We may combine a vegetable fat, such as olive oil, with precipitated casein, or fat-free lactic acid milk, and test its food value in acute diarrheas, or in convalescents from acute diarrheas, conditions in which the ordinary fats of milk are not well tolerated. I have had an opportunity so far to test the tolerance to olive oil in these acute infections in three cases only; one a convalescent from a severe infectious diarrhea, and two during an infectious diarrhea at the end of the first week of fever. In the convalescent case, the child, two and a half years of age, took two per cent. of olive oil in a fat-free lactic acid mixture and gained over a pound in four days. The case returned then to the country and I was not able to observe further its use.

In the other two cases the 1.50% of olive oil was given in a malt soup mixture. Both children, one one year, the other three years of age, have steadily improved. As the cases are far away from Boston and the parents have no means of weighing the children, my observation of the effect of the food is incomplete, but the result at least justifies the hope that such cases can be given food of higher caloric value by this method, with less disturbance of nutrition and greater conservation of strength. Dr. Wyman and I are planning more extensive and accurate

investigations along this line, through the courtesy of Dr. Bowditch, when the material which the Floating Hospital will furnish is available.

Mr. Howe is at present experimenting with the effect of an homogenized mixture, cotton seed oil and skim milk, upon calves. A perfect emulsion is obtainable. Whether such a food, which could obviously be produced at the minimum of cost, could be of use to infants, is at present interesting as a speculation only, but is worth investigation.

A more practical problem at once suggests itself in mixtures of olive oil and skim milk—especially in combination with the malt soup mixtures.

The type of food which I have found most useful in cases of fat indigestion with extreme malnutrition, is the malt soup mixture. Many of the worst cases are amenable to successful feeding by this method intelligently applied. However, we do meet with failures, and if we are to fairly test the applicability of an homogenized olive oil malt soup combination, we ought to select our cases from those who have been carefully fed in the past and yet failed to respond.

I have chosen olive oil for my first experiments, as olein is the principal fat of breast milk. The economic aspect of such a mixture, it seems to me, is of immense importance. The principal cost in milk modification depends upon the value of cow's fat or cream. Olive oil, even at ordinary retail prices, costs about one-fourth as much as cream. If combined with fat-free milk, the cost of a modified milk could be greatly reduced for the benefit of the poor, especially if we are able to demonstrate the possibility of keeping sweet and palatable, for several days a pasteurized homogenized milk.

Another point in connection with the malt soup olive oil mixtures is the effect of the homogenizing process upon the starch. The tendency for the barley decoction to separate on standing is strikingly prevented. In fact, any milk modification is improved in taste and appearance by this process of homogenization. It has been shown that whole milk so treated is more easily digested and assimilated. Homogenization of modified milks would, therefore, seem to increase their efficiency if used in cases in which there is no marked intolerance for cow's fat.

There are other fats and oils, besides olive oil, which I am planning to use as substitutes for cow's fat. Cod liver oil, for instance, homogenized with fat-free milk, or malt soup mixtures is fairly palatable as compared with ordinary methods of administration, but I have not yet tried it in a case of difficult fat digestion. Banana oil and the oil of the soja bean might also be tried.

Tonight I wish to call your attention to two cases only, which were my first selected difficult cases, both over two years of age, showing in one case, extreme, in the other, considerable, emacia-

tion, with intolerance for fat and failure to respond to the usual resources of feeding.

CASE 1. E. C. Age, 2½ years. Date of admission, Jan. 23, 1915.

Family History. Negative.

Past History. Instrumental delivery. Birth weight 9-10 pounds. Put on barley water and milk. Was kept on this for three months. Was then given milk, bread and butter. First teeth at 4½ months. Talked at 8 months. Walked at 1 year.

Present Illness. Five months ago began to vomit immediately after eating. Vomiting persisted. Child was put on Walker-Gordon formula for three weeks. Vomiting ceased. Then put back on bread, potatoes, butter and beef juice. Did not vomit. Two months ago vomiting began again. Diet changed frequently without relief. Abdomen became large one month ago, swelling would be noticeable for a day or two then would disappear. Has remained swollen the last three weeks. Bowels constipated, not remarkably. Swelling of hands and feet for the past two weeks. Losing weight for past four months. Frets a great deal. Appetite is good, no urinary symptoms.

Physical Examination. W. D. and P. N. Loss of weight evident. Very irritable, pale. *Head:* Normal. Eyes normal. Ears negative. *Mouth:* Teeth 6/6. Tongue moist and clean. Throat clear. *Neck:* Normal. Glands not enlarged. *Chest:* No rosary. Lungs normal. Heart normal. *Abdomen:* Distended, tympanitic. No masses, tenderness or fluid. Liver and spleen not felt. *Extremities:* Reflexes normal. Slight firm edema of both hands and feet, also of arms reaching just below elbows. *Skin:* Clear. W. B. C. 15,000. Hemoglobin 40%. Von Pirquet negative.

Jan. 24, 1915. Stool, light grey, non-formed, undigested potato. Acid reaction. No curds. Micro. Large excess of starch. Great excess of soap and fatty acid.

Jan. 25. R Low fat and low starch diet. Urine normal.

Jan. 31. Stool—light yellow, partially formed, saline like, slightly acid reaction. No curds. Micro. No neutral fat, no fatty acid. Considerable fat as soap, no starch. Persistent loss of weight and persistence of edema.

Feb. 1. Put on olive oil milk, 1.50 olive oil, 5.00 maltose, 1.75 protein, 0.75 barley starch, 5.00 lime water.

Feb. 2. Hungry, No vomiting. R 9 oz. 6 i. d. Barley jelly, b. i. d.

Feb. 5. Stool—large, soft, non-formed, light yellow. Few small, soft, yellow curds, faintly acid. Micro. Considerable neutral fat, no acid, no soap, no starch.

Feb. 6. Color better. Disposition greatly improved. Takes food eagerly. No vomiting. Bowels 1 to 2 i. d. Has lost 12 oz. since put on special mixture, probably due to absorption of edema, as the swelling of hands and feet has disappeared.

Feb. 8. Stool—light yellow, non-formed, saline-like. Few fat curds. Alkaline. Great excess of neutral fat.

Feb. 9. Gained 8 oz. last three days. Takes food easily, looks much brighter, better color.

Feb. 11. Stool—reaction acid. Moderate excess of neutral fat, no soap, no starch.

Feb. 12. Gain of 4 oz. daily for the last 7 days. Acts happy. Color better.

CASE I.

Feb. 15. Stool—partially formed, yellow. No curds, alkaline, small amount of neutral fat.

Feb. 15. Sore tongue. Normal temperature. Skin clear. Gained $1\frac{1}{2}$ pounds since put on special milk. Stools 1 to 2 i. d.

Feb. 18. Tongue much better. Stool—formed, yellow, no curds. Alkaline. Slight excess of neutral fat, no soap, no starch.

Feb. 20. Gained 8 oz. last four days. Hungry. Amount of fat in stools is gradually decreasing without cutting down the amount of fat in the milk. Patient actually smiled today.

R Barley jelly, two tablespoonfuls, b. i. d. Zwieback, one slice b. i. d.

Feb. 22. R 2.00 olive oil, 5.00 maltose, 1.75 protein, 0.75 barley starch, 5.00 lime water.

Feb. 23. Stool—light yellow, formed. Salve-like. No curds. Alkaline. Small amount of neutral fat, no fatty acids, no soap, no starch.

The net gain in three weeks since starting the homogenized olive oil malt soup mixture has been 2 pounds and 8 oz., an average gain of nearly 2 oz. a day. The disposition, appetite and general appearance of the child has improved in a corresponding degree.

CASE 2. E. D. Winchester, Mass. Seen on Aug. 31, 1914. Age, 22 months. Birth weight $7\frac{1}{2}$ pounds. Present weight 15 pounds 3 oz. First child. Breast-fed for 7 weeks, i.e. from Oct. 28 to Dec. 19, 1913, with a gain of about one-third pound only. From Dec. 19, 1912, to May 1, 1914, was given modified milk with many different formulae, containing sugar of milk, dextri maltose, Mellen's Food, etc. The net gain in four months was about $1\frac{3}{4}$ pounds. From May 1 to Aug. 26, 1913, was nursed by a wet nurse with a gain of 7 pounds. An attempt to introduce broth and cereals

CASE II.

at this time (10 months) resulted in a sharp intestinal indigestion with the loss of one-half pound in weight. For the remainder of the year, breast milk only was given and the baby reached her maximum weight of 18 pounds 14 ozs. at 12½ months.

The history of the feeding in the second year was one of unsuccessful attempts at weaning, resulting in an irregular but, on the whole, persistent loss of weight, until at the age of two years the weight had dropped to 13 pounds 3 ozs. The appearance was then that of a child mentally bright, but extremely emaciated and without signs of any organic disease. The von Pirquet reaction was negative. The stools were large in amount, of foul odor, with much free fat, fatty acids and soaps. During the second year, all the resources of several experienced pediatricists had been tried and types of feeding adapted to suit various theories which were held as to the cause of the indigestion and malnutrition. These included skimmed milk and fat-free malt soup mixtures, low fat malt soup mixtures, whole milk, goat's milk, and one period of six weeks on a general infant diet, without any milk. The results were much the same inasmuch as temporary periods of gains in weight would be followed by attacks of intestinal indigestion with rapid loss of weight, generally to a new low point.

On November 26 I first tried an homogenized milk with 2.00 fat (cow's), 5.00 maltose, 1.75 protein, 0.75 barley starch, 10% to the total mixture lime water, heated to 212°. With this was given, as before, the broth cultures of the bacillus lactic bulgaricus, and also panopepton. This resulted in a considerable improvement in appetite and a steady gain in weight of one-half pound in a week. Then came the usual "blow up," which differed from others only in that there was no marked intestinal indigestion; but the weight dropped to 13 pounds 3 ozs. again.

On Dec. 5, I used for the first time the olive oil malt soup mixture, starting with 1.00 olive oil, 5 maltose, 1.75 protein, and bicarbonate of soda, 2 grains to the ounce. In the following ten days there was rapid improvement, a gain in weight of 22 ounces, and a very striking improvement in appetite and general conditions. So ravenous in fact was the appetite, that the quantity had been increased to 56 ounces and the formula to 2.50 olive oil, 5.50 maltose, 1.75 protein, 0.75 barley starch, 2 grains bicarbonate of soda to the ounce, making 910 calories, or an energy quotient of 179. Then began a period of weight loss lasting for 5 days and reducing the weight to 13 pounds and 9 ozs. Whether this interesting decline was due to excessive feeding or to some disturbance in salt metabolism, brought about by the considerable amount of bicarbonate of soda (2 grains to the ounce) used during the period from Dec. 5 to Dec. 21, is difficult to determine. There was no loss of appetite or intestinal disturbance during this period of declining weight, but the stools showed a slight excess of soap and fatty acids. On Dec. 19, the olive oil was reduced to 1.50%, and on Dec. 20, the soda bicarbonate was omitted, lime water (5%) substituted and the homogenized milk, heated to 212° F. On Dec 21, immediately began a second period of gain in weight and in general condition, which has steadily progressed, in spite of a ten-day febrile attack with bronchitis. From Dec. 21 to Feb. 26 (67 days) the net gain has been 3 pounds and 14 ounces, or practically an ounce a day, on an average. The food has been increased gradually to 2.50

olive oil, 5.50 maltose, 2.50 protein, 0.75 barley starch. Both lime water and heat have been omitted. The stools are normal in appearance, showing no free fat, fatty acids, nor soaps since Jan. 2, 1915. The tolerance for fats and carbohydrates has steadily increased. Cereal jellies, broths and Zwieback have been added to the diet without precipitating a digestive crisis, and the whole appearance is one of rapid and permanent gain in disposition, strength and weight.

These results in the face of twelve months' steady decline under carefully-directed feeding by competent pediatricists, prove beyond any doubt the practicability of olive oil malt soup mixtures in certain selected, difficult cases of feeding. A wide field is open to determine their indications and limitations.

LUETIC BURSOPATHY OF VERNEUIL: REPORT OF A CASE OF THE CONGENITAL TYPE.*

By WM. PEARCE COUES, M.D., BOSTON.

Up to the time of Churchman's¹ classic article on this subject in 1909, the study of syphilis of the bursae had received but scant attention in America, though it had been written of in France, and had been recognized as of uncommon occurrence. The British writers on syphilis were silent on the subject, as Churchman points out in his article. Richet's classic early monograph on the clinical features of specific arthropathies does not mention specific bursitis. The elder Keys² was the first to call attention to the subject in America, though his article did not receive the attention it deserved, in making the condition generally known. He does not mention the possibility of specific bursitis in congenital syphilis. It was to Verneuil³ that the credit belongs of first describing the conditions of specific bursitis. A few words concerning him are of interest in this connection.

Aristides Auguste Stanislos Verneuil was born in Paris in 1823 and died at Maison Lafite in 1895. He studied medicine in Paris and was an intern of the Paris hospitals. He was appointed assistant in anatomy in 1848, became *aggrégé* in 1853, and was professor of pathology in 1858. Some of his important contributions were Investigations Concerning the Movements of the Heart, in 1852, Anatomy and Physiology of the Venous System in 1853. Verneuil studied the etiology of tetanus and his experimental and clinical studies of tuberculosis were the means of causing the first Congress on Tuberculosis, which was held in Paris in 1888. Among his shorter but important contributions were articles on anthrax of the lip and of the mucous membranes, resection of the hip, and separation of the lower epiphysis of the femur. It does not seem strange

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