CHITTENDEN (R.H.)

A STUDY OF SOME INFANT FOODS IN COMPARISON WITH MOTHERS' MILK.

By R. H. CHITTENDEN, Ph.D., Professor of Physiological Chemistry in Yale University. Reprinted from the *New York Medical Journal*, July 18, 1896 : : :

THE DEFICIENCY OF FAT IN DRY MILK-FOODS FOR INFANTS

By R. H. CHITTENDEN, Ph.D., Professor of Physiological Chemistry in Yale University. Reprinted from the *Dietetic and Hygienic Gazette*, October, 1895 : : :

THE CONTENT OF FAT IN DRY MILK-FOODS FOR INFANTS

By R. H. CHITTENDEN, Ph.D., Professor of Physiological Chemistry in Yale University. Reprinted from the *Dietetic and Hygienic Gazette*, January, 1896 : : :

A STUDY OF SOME INFANT FOODS IN COMPARISON WITH MOTHERS' MILK.

By R. H. CHITTENDEN, Ph.D.,
PROFESSOR OF PHYSIOLOGICAL CHEMISTRY IN YALE UNIVERSITY.

Reprinted from the *N. Y. Medical Journal*, July 18, 1896.

The tendency in infant feeding at the present time is clearly toward as close an approximation as possible to woman's milk—to the scientific rather than the empirical method. In view of this fact, it has seemed to the writer a matter of importance to ascertain how near some of the more widely used infant foods approach to this now theoretically accepted standard.

Owing to the varied nature of the so-called "infant" foods—to the lack of any recognized standard of composition for the various sorts of foods, farinaceous, malted, Liebig, etc.—it becomes evident that the most practical and most satisfactory method of comparing an infant food with mothers' milk is to analyze the food as it is prepared for the nursing bottle. Due weight must necessarily be given to the directions for preparing the food for use ; for these are plainly of primary importance in determining the real food character and value of the product. It is the food in the nursing-bottle that is fed to the infant, and it is the composition of this product that we need knowledge of. Some of the directions, however, are so vague and offer such a wide variation in the proportion of the several ingredients that it would seem

as if they were purely empirical and designed simply to give some food which would in some way agree with the child.

It should be pointed out, however, that many of these foods do not specifically purport to resemble mothers' milk. The general tenor of their makers' statements is that they add something to enrich or improve cows' milk for the nutrition of an infant; for instance, that cows' milk is, by the process of manufacture, by the drying with farinaceous and saccharine matters, made more digestible and wholesome for the infant, or that the addition of malted grains renders the milk more suitable, or better adapted for an infant's food. Moreover, the physical properties and characteristics of most of these foods are such that it would be difficult to suppose it was ever intended that they should resemble mothers' milk. It is, however, contended for nearly all these foods that the casein is in some way rendered digestible, so that it will curdle like mothers' milk, etc.

In preparing these foods for analysis, the directions given by the manufacturer have been followed as closely as possible, and where, as in the case of some of the foods, different proportions are recommended for different ages, the food has been prepared as directed for infants of six months, this being deemed the best course to pursue for comparative study; thus placing all on a fair basis, each to the other, as to the relative composition of the foods as actually in use at six to twelve months.

The analyses, therefore, present the composition of the several foods when ready for the nursing-bottle, with water, milk, and cream added as specified in the directions. The accompanying table gives the results obtained, expressed in parts per hundred.

Composition of some Infant Foods as prepared for the Nursing-Bottle in comparison with Mothers' Milk. Prepared according to Directions for Infants of Six Months.

	Mothers' milk.*	Malted milk.	Nestlé's milk food.	Imperial granum.	Mellin's food.	Peptogenic milk powder.
Specific gravity....	1031	1025	1024	1025	1031	1032
Water.....	86.73	92.47	92.76	91.53	88.00	86.03
Total solid matter †	13.26	7.43	7.24	8.47	12.00	13.97
Inorganic salts	0.20	0.29	0.13	0.34	0.47	0.26
Total albuminoids.	2.00	1.15	0.81	2.15	2.62	2.09
Soluble albuminoids	2.00	1.15	0.36	1.67	2.62	2.09
Insoluble albuminoids.....	0	trace	0.45	0.48	0	0
Fat.....	4.13	0.68	0.36	1.54	2.89	4.38
Milk sugar.....	6.93	1.18	0.84	2.71	3.25	7.26
Cane sugar.....	0	0	2.57	0	0	0
Maltose	0	3.28	trace	trace	2.20	0
Dextrin	0	0.92	0.44	0.58	0.53	0
Soluble starch....	0	0			0	0
Starch.....	0	0	1.99	1.22	0	0
Reaction	alkaline	alkaline	alkaline	alkaline	alkaline	alkaline

In the following discussion of these foods, it is the food as prepared for the nursing-bottle that is to be understood as referred to.

A careful study of these results reveals many interesting facts. Thus, only two of the foods show a specific gravity at all analogous to that which is usually taken as the average for mothers' milk; and these two foods contain an amount of solid matter not far removed from that of mothers' milk. The others have a comparatively low density in harmony with their smaller proportion of solid matter, two, as the table shows, having but about fifty-four per cent. and one sixty-three per cent. of the solid matter present in mothers' milk. Hence, whatever the character of this solid matter, these three foods are far weaker fluids than ordinary breast milk.

* According to Leeds. † By direct determination.

The very great difference in the physical properties of these foods should be mentioned, especially in view of the fact that some of the foods when warm are comparatively fluid and become quite thick or gelatinous upon cooling.

Just here, it is well to remember that the solubility of the constituents of milk does not depend upon temperature. Lactose, mineral salts, and maltose are readily soluble in cold milk as well as in cold water; so that cows' milk, or a properly modified milk, is not noticeably thinner when warm than when cold. When, however, fresh milk has been evaporated to dryness, the solid matter so obtained is not soluble or readily diffusible in water, owing to the incorporation of hard casein and fat. In Nestlé's milk food, for instance, there is a very rapid separation of the milk mixture into two distinct layers—viz., an upper thin layer, and a heavier layer containing considerable insoluble albuminoid and starch.

The thickness of a food such as Nestlé's and imperial granum particularly is undoubtedly due to the presence of starch, which thus shows its characteristic behavior upon mixing with water and boiling.

With regard to the amount of mineral matter, two contain approximately the same percentage as mothers' milk, while the others have either an excess or deficiency of these important elements, the excess being in all cases due chiefly to alkaline carbonates. Although the proportion of inorganic salts present in milk is small, the importance of mineral matters in the nutrition of the infant is not to be ignored or lightly passed over. The growing infant must have a bony framework to support its rapidly developing tissue, and if the necessary elements are not contained in its daily food, how are they obtained?

The albuminoids which are so essential for the growth and well-being of the animal organism, whether young or old, are seen to vary in these foods from 0.81 to 2.62 per cent. Compared with mothers' milk, all but two show wide variations. Imperial granum and milk modified by peptogenic milk powder, however, contain practically the same amount of albuminoids as average breast milk. Mellin's food, on the other hand, contains thirty-one per cent. more albuminoids than mothers' milk itself; malted milk has fifty-seven per cent. and Nestlé's food forty per cent. of the albuminoids present in mothers' milk.

It is to be noted, further, that differences exist in the character of the albuminoids present, as indicated by the fact that in some of the foods a certain proportion of the albuminoids is in an insoluble form. Thus, in imperial granum, more than one fourth of the total albuminoids are insoluble. In Nestlé's food more than one half of the albuminoids are in an insoluble form.

There are still other differences, not shown in the analyses, that need to be considered in connection with the albuminoidal matter of these foods. Thus it is a well-known fact that the albuminoids of human milk differ in a number of ways from the corresponding bodies in cows' milk. Leaving differences in chemical composition, etc., out of consideration, we may merely call attention to the way in which casein behaves when fresh cows' milk is mixed with dilute acid, as the hydrochloric acid of the gastric juice. Woman's milk, when mixed with dilute acid, such as 1-per-cent. acetic acid, or 0.2-per-cent. hydrochloric acid, yields a soft, flocculent precipitate of albuminoid, which is very different from the tough and solid curd formed in cows' milk. The difference is not due merely to difference in the proportion

of albuminoid contained in the two milks, but rather to the nature of the substance itself. Simple dilution of cows' milk with water is without avail in obviating this tendency of the milk to form tough and more or less indigestible curds. It is obvious, therefore, that any method of modifying cows' milk that aims to produce a product analogous to mothers' milk must take into account this radical difference in the nature of the two caseins.

The very first step in the process of digestion is the precipitation of the casein in the stomach by the combined action of the acid of the gastric juice and the rennet ferment, and with a weak stomach the form in which the casein is precipitated is a matter of some moment. As to how far this difference has been taken into account in the preparation of the foods under consideration, we can in a measure judge from the behavior of the several foods toward dilute acid.

This may be readily ascertained by placing a given amount, say five cubic centimetres of 0.2-per-cent. hydrochloric acid, on a watch glass, and then allowing the food to fall, drop by drop, upon the acid.

A simple and suggestive method is also to take some bulk, say two ounces of the warm food, in a glass and add the acid little by little, stirring gently. Tested by these methods, it will be found that malted milk and Nestlé's food both yield a fine, flocculent precipitate on the addition of acid. Of malted milk it is stated that the casein of the milk of this food is altered by the action of plant pepsin, as a part of the process of manufacture. The incorporation of fresh, unaltered cows' milk with saccharine and farinaceous matters, and concentration and reduction to a dry pulverulent form, must result in a food containing casein in fine, hard, granular par-

ticles, and this may account for the fact that a dried milk food like Nestlé's, when diluted and prepared with water, does not behave at all like fresh milk casein to dilute acid.

We have a striking illustration of this in the behavior of Mellin's food with the acid. Here the casein separates in flocks or curds when the dilute acid is added to the prepared food, thus showing that the addition of soluble maltose and dextrin to fresh milk does not of itself noticeably modify the character of the casein.

In milk modified by the imperial granum, the addition of acid causes a very thick separation of the casein, and the separated casein appears gelatinous rather than curdy, due probably to its intimate mixture with the starch paste of the imperial granum. The lack of the true casein curd common to cows' milk upon the addition of acid is not due in this case to solubility of the casein. It is the result evidently of mechanical mixture of farinaceous matter with the casein, by which the precipitated proteid is kept more finely divided. Further, it must not be overlooked that this result is accomplished by the addition of a substance wholly foreign to the natural food of an infant, and it may well be questioned whether such a mixture is well adapted to its normal digestive functions.

In milk modified by the peptogenic powder, the specific statement is made that the albuminoids of the milk are truly modified by the process to which they are exposed when the diluted milk and cream are warmed with a specified amount of the powder. In conformity with this statement it is found that the precipitate produced by acid, while naturally bulky from the due amount of albuminoids present, is composed of soft, non-adherent coagula. It is further evident, from the

bulk of this precipitate, that the proteolytic action made use of in the preparation of the milk for the bottle has by no means resulted in the complete digestion of the proteids of the milk, the transformation resulting simply in a modification of the casein, with solution of a small amount of proteid, so that the precipitate produced by acid is much less bulky and less coherent than that from similarly diluted cows' milk, to which has been merely added maltose or lactose. So far as our results show, cows' milk, modified by peptogenic milk powder, is not to be classed with predigested foods, for the reason that the proteids of the milk are so altered as to render them closely analogous to the proteids of mothers' milk without converting them wholly into soluble albumoses and peptone.

These observations naturally raise the question of whether any of these foods, when made ready for the nursing-bottle, contain active forms of enzymes of any sort, particularly proteolytic or amylolytic. So far as we can find, the answer to this question is entirely in the negative. None of these foods when prepared for use contain any active enzyme capable of converting either starch or proteid.

The enzyme of the peptogenic milk powder is obviously destroyed in the boiling to which the fluid is subjected during the preparation of the food. Hence the conclusion that all of these foods when prepared for the nursing-bottle are to be judged solely on the basis of their food value, since none of them possess any recognizable digestive power.

Neither is any one particularly or unduly digestible as compared with mothers' milk. Their utilization by the system depends wholly upon the digestive power of the infant's own secretions.

With reference to the quantity of fat contained in the several foods when prepared for use, only one contains any approach whatever to the amount characteristic of mothers' milk. In the food prepared by the peptogenic milk powder the natural deficiency of fat which results from the dilution of cows' milk has been overcome by the addition of a certain amount of cream, an addition which, as the analyses show, is fully competent to attain the end in view. In all the other foods the deficiency of fat is marked, as the table of analyses shows. The necessity and importance of adding cream or fat to fresh cows' milk, in order to bring the proportion of fat up to that of mothers' milk, is here well illustrated, while the deficiency of fat in the foods prepared with the dried milk products is extreme—very far below that of mothers' milk.

The carbohydrate material of mothers' milk, as well as of cows' milk, is composed solely of milk sugar. In human milk the average amount, according to Leeds, is 6.93, while in cows' milk the percentage of the sugar is nearer 4.5. In malted milk and in Mellin's food the total carbohydrate matter, represented by milk sugar, maltose, and dextrin, is not widely divergent from that of breast milk. It is to be remembered, however, that maltose and dextrin are foreign substances, not contained either in cows' milk or human milk, and, while both are undoubtedly possessed of high food value, yet it is equally evident that Nature gives preference to milk sugar or lactose as the proper form of carbohydrates for the nutrition of an infant.

As soon as the growing infant acquires the ability to subsist upon solid foods the farinaceous matters naturally consumed are converted into dextrins and maltose by the enzymes of the several digestive juices. But, prior to

this period, the food provided by Nature for the sustenance of the young is characterized by the complete absence of every form of carbohydrate matter except milk sugar. It may be said that infants thrive as well upon maltose or sucrose as lactose, but in the writer's judgment there is no good ground for such an assertion. It may be true, but positive proof is wanting. However, at the present time, the writer's purpose is to simply call attention to certain facts bearing upon the chemical composition of infant foods in their relation to mothers' milk ; and, limiting ourselves to this point, we see on reference to the table, that only one product compares with breast milk in the kind and proportion of sugar present. All the others contain more or less milk sugar; but in addition to this carbohydrate they are characterized by the presence of variable amounts of maltose, dextrin, cane sugar, soluble starch, or starch, all of which are foreign to natural milk.

The writer would not be understood as speaking in a derogatory way of any of these food products, or as eulogizing one product at the expense of another. They are all, no doubt, of value and useful, but with one exception, when prepared for use, they show wide variation from the composition of human breast milk. It may, perhaps, be a matter of opinion as to what constitutes the best diet for a young infant; but if we are to adopt mothers' milk as the standard, then it is well for us to consider how far and in what respect the infant foods widely used differ from this standard.

Cows' milk is without question the best material available for the nutrition of the infant when the latter is deprived of its natural food, and any modification that will render this fluid more closely analogous to breast milk is certainly to be recommended on physiological

grounds. That there is no special difficulty in modifying cows' milk so that it will resemble mothers' milk, both qualitatively and quantitatively, is clearly apparent from the analytical results shown in the table. Cows' milk, modified by the addition of water, cream, and peptogenic milk powder, offers a product containing to the full extent all of the proximate principles present in human breast milk and wholly free from extraneous admixtures. The proportion of solid matter, fat, albuminoids, carbohydrate, and inorganic salts corresponds as closely as one could ask with what is considered as the average chemical composition of mothers' milk, and in this respect the product differs notably from all of the other products examined. Further, the process of modification takes into account the radical difference between cows' casein and human casein, and affords a method by which the former can be modified to a closer resemblance to the latter without the addition of any substance that will permanently interfere with the purity of the final product.

The general resemblance of milk modified by the peptogenic milk powder to the infant's natural supply is a very striking one. The logical outcome of the present scientific attitudes must ultimately place infant feeding on a practical, exact basis, which will supersede the empiricism which has too long prevailed. In the consistent pursuit of this scientific attitude lies the only hope of any real progress.

THE DEFICIENCY OF FAT IN DRY MILK-FOODS FOR INFANTS.

By R. H. CHITTENDEN, Ph.D.,

PROFESSOR OF PHYSIOLOGICAL CHEMISTRY IN YALE UNIVERSITY.

Reprinted from *The Dietetic and Hygienic Gazette*, October, 1895.

In the May number of *The Gazette* we called attention in a general way to the desirability of pure foods for both adults and infants, and suggested a possible remedy for existing evils. We must admit, however, that perhaps the best remedy at present lies in the education of the people, so that they may have an adequate understanding of the dangers, both positive and negative, attending the use of impure foods. With proper enlightenment on this point more strict enforcement of existing laws will naturally be called for, and we may then look for greater freedom from foods of questionable purity. With this end in view, we desire in the present article to call special attention to what seems to the writer a serious evil in connection with a certain class of infant foods.

Among the various foods offered for the use of invalids and young infants none appeal to the physician and to the public more strongly than the so-called dry milk-foods prepared by the evaporation of fresh milk, because of the natural inference that such foods must necessarily constitute a model diet, especially for infants where mothers' milk is unavailable. Purity and concentration both seem assured, and the purchaser of such foods

naturally assumes that he is obtaining an article the equivalent in every sense of pure, fresh milk. Chemists, indeed, have long sought to make a dry milk which would satisfactorily take the place of fresh milk, but so far as the writer is aware a product which strictly fulfils all the requirements has not yet been made. Condensed milk still remains the chief reliance for dietetic purposes in all situations where fresh milk is not obtainable, but the physician well knows that for the nutrition of the infant condensed milk is far from being an ideal food. The process of condensation as ordinarily conducted enables us to so concentrate the milk that approximately two-thirds of the water can be removed and the constituents of the milk preserved in their original condition. This process, however, entails the addition of cane sugar to such an extent that the finished product contains about 40 per cent. of the sugar, thus making up about 55 per cent. of the total solid matter. If now such a condensed milk is diluted with water so as to bring the albuminoids and fats to a correspondence with the original cows' milk, it will contain approximately 16 to 17 per cent. of cane sugar, and be altogether too sweet for use as an infant food, to say nothing of the danger attending the introduction of such a large amount of easily fermentable sugar into the gastro-intestinal tract of a young infant. If, on the other hand, the condensed milk be so diluted with water that the sweetness is made comparable to that of fresh milk, either human or cows', then the product becomes greatly deficient in fats, albuminoids, and salts ; i.e., its nutritive value falls far below that of fresh milk. For these reasons condensed milk can hardly be recommended as an ideal food for infants, although there may be times and places where its use becomes necessary.

The suggestion naturally presents itself in this connection, why not condense milk without the addition of cane sugar? Theoretically, this seems quite simple, but in reality the carrying out of the process is liable to be attended with certain undesirable results. Thus, if pure milk is evaporated to a density approaching that of the sweetened product the milk sugar crystallizes out, and if not concentrated very densely the cream separates and the product does not keep well when once opened. Practically, then, unsweetened condensed milk is less likely to be successful commercially.

To one unfamiliar with the action of heat, long continued, on milk, the thought might naturally present itself, why not simply evaporate *pure* milk to a dry powder? If this could be accomplished in such a manner that the resultant product would dissolve in water and yield a fluid really milk, it would be a satisfactory solution of the problem; but this cannot at present be done. In order to thoroughly understand the problem, consider for a moment the chemical composition of pure cows' milk. It contains, on an average, 87 per cent. of water and 13 per cent. of solid matter, of which nearly one-third is fat. Now, on the evaporation of this fluid to dryness, so as to remove the 87 per cent. of water, there will obviously remain a solid residue, of which 30 per cent., or even more in the case of a rich country milk, will be composed of fat; i.e., it will be so rich in fat as to constitute an entirely impracticable product. Further, the drying necessary to accomplish this result has a marked effect on the fat; it loses its peculiar emulsified condition and cannot now be diffused or suspended in water, as in the original milk. Moreover, it acquires a brownish color, and is very prone to become rancid. Butter fat, as is well known, melts at a comparatively low tempera-

ture, and a dry product containing 30 per cent. or more of such a fat must necessarily be very unstable and prone to become rancid, especially when exposed to the air in warm weather. Again, the process of drying has a marked influence upon the casein of the milk, rendering it hard and insoluble, so that it will not dissolve in water and regain its characteristic condition. These difficulties may be overcome somewhat by the incorporation of cane sugar and lactose, but this does not protect the fat from change, and the addition of these sugars naturally defeats the object in view, since the product is not then a pure dried milk.

It is thus manifest from the foregoing statements that it is practically impossible to prepare a *pure* dry milk which by the mere addition of water will yield a fluid at all analogous to fresh milk, and yet dried milk-foods are widely used in the nourishment of infants. That they are so used is due no doubt to the supposition on the part of the purchaser that the foods are made from *pure* fresh milk, and that they are in many respects more desirable than ordinary milk. Indeed, the specific claim is made by some of these foods that they are superior to ordinary milk, especially in the fact that they are composed of "pure, rich cows' milk," combined with other substances designed to make the product "resemble very closely the infant's natural supply."

We may thus properly inquire whether these dry milk foods fairly represent average milk in the percentage of one of its most important elements, viz.: the fat? Do they, when prepared for the bottle, afford an equivalent to ordinary fresh milk-foods in the percentage of cream, and do they resemble very closely mothers' milk in their content of fat? The dry milk-foods most commonly used are of two distinct kinds—one, milk concentrated

to dryness with malted cereals ; the other, milk evaporated to dryness with baked farinaceous substances and cane sugar. A sample of "malted milk" recently analyzed by the writer was found to contain 1.94 per cent. of fat. Assuming malted milk to be made by the concentration of pure, whole milk of average richness, the above percentage of fat would indicate that the actual milk solids had been incorporated with say fifteen times their weight of other solids—of the dried malt. If such is the case, this dry milk-food contains a very small proportion of milk. Far more plausible is the supposition that the food in question is prepared not from whole milk, but from skimmed milk, or from milk from which a portion of the cream had been removed. The correctness of this supposition is indeed indicated by the relative proportion of albuminoids, fat, and malt derivatives contained in the product. The actual fat present in dry malted milk is a little more than half that ordinarily present in good cows' milk and about one-fifteenth that present in pure dry milk.

"Malted milk" when prepared with the maximum amount of water directed for an infant under three months contains 0.12 per cent. of fat. Prepared with the minimum amount of water directed for infants from six to twelve months, it contains 0.21 per cent. of fat. Hence the young infant fed solely on such a diet will have a food containing in the first instance only one-thirty-fourth, and in the second case only one-twentieth the amount of fat present in mothers' milk—mothers' milk containing 4 per cent. of fat.

As a sample of the other class of dry milk-foods, we may mention "Lacteous Farina," which contains from an analysis recently made, 4.91 per cent. of fat. Here the amount of fat is greater than in the preceding prepara

tion, but is less than one-sixth the amount contained in pure, dry cows' milk. If "Lacteous Farina" is prepared for the feeding-bottle as directed for an infant of three months old, the mixture will contain 0.29 per cent. of fat, while for a child six months old the proportion of dry food and water called for in the directions will make a mixture containing 0.38 per cent. of fat. Hence a young infant limited to such a diet will have a food containing only one-thirteenth the amount of fat present in mothers' milk.

These facts certainly raise the question whether the advantages connected with the use of these dry milk-foods are sufficient to compensate for the practical deprivation of cream which the infant fed upon such foods must endure. In the increasing scientific tendency of infant feeding, and in the widely recognized practice of modifying cows' milk to a correspondence with human milk, the importance of cream as an element of the infant's food is almost universally recognized. Yet, as we have seen, these so-called milk-foods are wofully deficient in this important element. The addition of fresh cream is evidently more essential in the use of these foods than it is with ordinary fresh milk, as commonly diluted and prepared.

If we give due weight to the chemical composition of these dried milk-foods, and especially to their low content of fat, we are at once confronted with the suggestion that the foods in question are manufactured from skimmed milk, not for the sake of economy, but simply because the fat, if retained, would tend to spoil the food, for reasons already mentioned, and ultimately render it unsalable. There seems no plausible explanation of the composition of these foods other than the one just given, unless we suppose that the amount of whole milk used

in the preparation of the food is very small, in which case there is no justification for the use of the name "milk-food."

Apart from the consideration of these dry milk-foods as representing cows' milk in chemical composition and nutritive value, the question may be raised as to whether they are not amenable to the laws by which the sale of milk and food is regulated. By the laws of the State of New York, for instance, a food is defined as adulterated, first, "if its strength or purity falls below the professed standard under which it is sold." Third, "if any valuable constituent of the article has been wholly or in part abstracted." So far as we are aware there is no intimation that in the manufacture of these foods any portion of the fat of the milk has been removed. On the contrary, on the circular accompanying one food of this class is the statement that the basis of the food is "choice milk from Swiss cows, concentrated in vacuo at a low temperature, so as to preserve its original valuable qualities unchanged." The sale of skimmed milk is properly prohibited by law, and there would seem to be no reason why a dry milk-food for infants should not be amenable to the same law, especially when it is remembered that the chief arguments for the regulation of the milk supply are found in its large use as a food for infants and young children. So long as these foods are sold with the claim that they represent pure, fresh milk, or that they "show a close resemblance to mothers' milk," they are certainly open to criticism, for at the present day, when the tendency in infant feeding is toward as close an approach as possible to mothers' milk, the marked deficiency in fat in the above foods cannot be overlooked. Fat is an essential element in the nutrition of the infant, as well as of the adult, and its place cannot

be wholly taken by carbohydrates. It would seem wisest to follow nature's leading, and when the infant is deprived of its natural nourishment to supply a food which approximates as closely as possible to mothers' milk, and if we are to adopt this law, due weight must be given to the fat or cream, which is such a conspicuous element. It is, therefore, very questionable whether the manufacturing necessity of leaving out the cream, in part at least, in making a commercial milk product, is sufficient justification for the use of foods so deficient in one of the chief elements of "pure, rich milk."

THE CONTENT OF FAT IN DRY MILK-FOOD FOR INFANTS.

By R. H. CHITTENDEN, Ph.D.,
PROFESSOR OF PHYSIOLOGICAL CHEMISTRY IN YALE UNIVERSITY.

Reprinted from *The Dietetic and Hygienic Gazette*, January, 1896.

In the October number of *The Gazette* (1895) attention was called to the deficiency of fat in dry milk-foods for infants as compared with mothers' milk, and emphasis was laid upon the practical impossibility of manufacturing successfully a dry food by the evaporation of pure cows' milk, which on solution in water would yield a fluid resembling or analogous to mothers' milk, especially in its content of fat. Further, in this connection analytical results were given showing that at least two widely used dry milk-foods, when prepared for the nursing-bottle as directed, contained a very much smaller amount of fat than human breast milk. Since the above paper was written, however, certain facts have come to the writer's notice which have necessitated a reconsideration of this question, and although the work we have done in this direction has not led to any material modification of our views upon the main subject, it has emphasized the importance of carefully considering the methods now in use for the determination of fat in dry food-products, and rendered necessary a modification or correction of some of our previous statements.

The analytical chemist, whose work lies mainly in the

domain of organic or physiological chemistry, would probably consider a determination of the amount of fat in a dry and finely pulverized substance as a simple operation. The conventional method, in use now for many years, consists merely in thoroughly extracting a weighed amount of the powder with warm anhydrous ether—preferably in some form of extraction-apparatus, such as Soxhlet's—and weighing the fat so abstracted, after suitable drying at 100° C. This is the method universally used, and so far as I am aware it has never been the subject of any decided criticism. By such a method as this the writer found on analysis of a sample of "malted milk" 1.94 per cent. of fat, the duplicate determinations agreeing so closely that the possibility of error was obviously not to be considered. Shortly after the publication of the above article a paper was received from the physiological institute at Bonn,* calling attention to the fact that dry, finely pulverized muscular tissue—freed from all visible fat—gives up its contained fat to ether very slowly and incompletely. Indeed, Dormeyer states that even after 100 hours' continuous extraction with anhydrous ether in a Soxhlet apparatus only $\frac{1}{6}$–$\frac{1}{4}$ of the contained fat can be removed, even though the material be brought to the finest state of division. The full complement of fat was obtained only by digesting the muscle-tissue with active gastric juice and then extracting the resultant solution with ether. The fat was found to be ordinary neutral fat, readily saponifiable by alkali. At about this same time the writer received a letter from Dr. R. C. Hindley, chemist to the "malted milk" company, stating that the amount

* Die quantitative Bestimmung von Fett in thierischen Organen. Vorläufige Mittheilung von Dr. Phil. C. Dormeyer, *Fflüger's Archiv f. Physiol.*, Band 61, p. 341.

of fat contained in this product was much greater than had been reported.

These facts naturally led to a reconsideration of the matter ; analysis of the product was repeated, and to make the trial as thorough as possible two determinations were made upon widely different amounts of material. The extraction with anhydrous ether was made in an ordinary Soxhlet apparatus, and was continued for eight hours with the following results :

	"Malted milk" employed.	Amount of fat found.	Percentage of fat.
(A)	2.1401 grams.	0.0425 gram.	1.98
(B)	5.6738 "	0.1105 "	1.94

Especially noticeable is the close agreement of these two results ; an agreement which, taken in connection with the wide difference in the amount of substance employed, gives an air of accuracy quite convincing. Indeed, it is very plain that the dry powder contains only 2 per cent. of fat capable of being extracted by ether, and yet these figures represent only about one-fourth of the total amount of fat actually present in the preparation. In other words, the ordinary method of extracting fat from a dry and finely divided powder will not remove from the " malted milk " powder more than one-fourth of the contained fat.

That this preparation contains a far larger amount of fat than was at first reported we have been able to demonstrate by the following method : Dissolve, say 0.8 gram of the powder in about 8 c. c. of warm water, and allow the fluid to be absorbed by a fairly large bulk of freshly ignited asbestos-wool contained in a Schleicher and Schüll paper cylinder (such as is used for fat extractions), using 1–2 c. c. of distilled water to transfer

the fluid wholly to the asbestos. By this method the fat-containing fluid is distributed over a large surface, after which the paper cylinder with its contents is dried in an air-bath at about 50°–60° C. for some hours, and finally for about two hours at 100° C. The cylinder is then introduced into a Soxhlet tube, and extracted with ether for 7–8 hours, etc. The following figures obtained with the sample of "malted milk" previously analyzed may be quoted as showing the character of the results yielded by this method :

	"Malted milk" employed.	Amount of fat found.	Percentage of fat.
(A)	0.8079 gram.	0.0642 gram.	7.94
(B)	0.8079 "	0.0635 "	7.85
(C)	0.8333 "	0.0659 "	7.90
(D)	0.8333 "	0.0658 "	7.89
(E)	0.8333 "	0.0665 "	7.98
(F)	0.8333 "	0.0670 "	8.04

Especially noteworthy is the fact that the yield of fat by this method is just about four times the amount obtainable by direct extraction of the dry powder with ether, thus agreeing with Dormeyer's statement concerning dry and finely pulverized muscle-tissue. These results certainly raise a doubt concerning the reliability of the ordinary method for the determination of fat in such products, and render it necessary for the careful chemist to consider this possible source of error. Whether this danger is widespread, or whether it is limited to certain peculiar or specific mixtures or products, the writer does not know. At first glance it might be assumed that this difficulty of completely extracting the fat with ether is purely a mechanical one, dependent upon the possible lack of fine division of the particles,

or to the compact packing of the powder in the extractor. These suggestions, however, are quickly negatived by the fact that several products resembling "malted milk" in their physical properties, recently analyzed by the writer, yield their contained fat readily and completely to ether by the ordinary method of extraction. Again, the close agreement in the results obtained with such widely different amounts of "malted milk" powder as 2.1 grams and 5.6 grams, otherwise under like conditions, suggests that a certain proportion of the fat—one-fourth—exists free, while the remaining three-fourths exist in some loose combination with the carbohydrate or albuminous matter of the compound; and in this connection the close analogy of these results with the results reported by Dormeyer in the analysis of muscle-tissue is quite striking and suggestive. Unless we accept some such explanation as the above, it is difficult to understand why the fat in "malted milk" should not be as readily dissolved by ether as that contained in similar products. Several hours' continuous extraction with ether would seemingly be sufficient to entirely remove the fat present, no matter how closely it may be blended, or how intimately it may be mixed with the saccharine and other soluble constituents of the malted cereals used in the preparation of "malted milk," assuming no chemical combination to exist.

Whatever the true explanation may be, it is very plain that the sample of "malted milk" examined by the writer contains at least 8 per cent. of available fat According to Dr. Hindley, "malted milk" is intended to contain on an average 8.5 per cent. of fat. This statement the writer is quite willing to accept, although in this particular sample he has not been able to obtain evidence of more than 8.04 per cent. Dr. Hindley also

states that he likewise "finds it impossible to extract from the powder much more than 2 per cent. of fat by the ordinary method." He employs a method for determining the fat similar to that used by the writer, and he lays special stress upon the necessity of drying the aqueous solution of the powder at a low temperature so as to prevent "caking" of the product.

We regret exceedingly the publication of any statement not strictly accurate, and consequently take pleasure in making the above correction. At the same time, candor compels us to express the opinion that the responsibility for this misstatement rests mainly with the manufacturers of this food-product. The product is issued without statement as to its chemical composition other than that it is "composed of pure, rich cow's milk combined with an extract of malted grain," and that "its chemical, physical, and physiological properties resemble very closely the infant's natural supply." The fat of mothers' milk offers no such difficulty in its extraction with ether, and hence the chemist unfamiliar with the product would have no cause to suspect the inadequacy of the ordinary methods of analysis. The manufacturers, however, being well aware that only one-fourth of the contained fat could be detected by the ordinary method of extraction, have, it seems to the writer, voluntarily put themselves in a position where their product might be misjudged.

However this may be, it is obviously necessary, in view of the facts, that some of the statements made in the preceding paper upon this subject should be modified. Thus, "malted milk," assuming a content of 8.5 per cent. of fat, when prepared for the nursing-bottle with the maximum amount of water directed for an infant from three to six months would contain about 0.48

per cent. of fat, *i.e.*, one-eighth the amount of fat present in mother's milk—mother's milk containing 4 per cent. of fat. Prepared as indicated for infants of six months, the mixture would contain 0.64 per cent. of fat, while with the minimum amount of water specified for infants from six to twelve months the prepared food would contain about 0.93 per cent. of fat. Hence, the young infant fed solely upon such a diet will in the two last instances have a food with about one-sixth to one-fourth the amount of fat contained in mother's milk. Our inquiry was originally intended to call attention simply to the deficiency of fat in dry milk-foods for infants as compared with mother's milk, believing as we do that the best and most natural food for the infant is that which approximates most closely to the infant's natural supply. The corrections we have made in regard to the fat content of "malted milk" plainly show that this deficiency of fat is not as great as was originally stated, but it is equally evident that a deficiency exists, and to a very noticeable degree, in comparison with mother's milk. We can therefore make no exception to the general statement previously made that in the use of dry milk-foods the addition of fresh cream is as essential or more so than it is with ordinary fresh milk as commonly diluted and prepared. We are well aware that the food in question contains considerable dextrin as well as maltose, but we do not believe that these are perfect substitutes for the deficient fat. An infant, no doubt may manufacture fat from carbohydrates, but nature evidently has some reason for supplying the young infant with the large amount of fat contained in mother's milk, and there would seem to be no justification for the claim that dry milk-foods resemble very closely in chemical and physiological properties the infant's natural supply,

when there is this marked deficiency of fat, and a large substitution of maltose and dextrin, both of which are absent from human milk.

Malted milk as well as other dry milk-foods are no doubt possessed of high nutritive value, but there should be a clear recognition of the fact that such foods when contrasted with mother's milk, are greatly deficient in the fat which is so characteristic of the latter fluid.

Again, in our previous paper upon this subject the suggestion was made that the comparatively small amount of fat contained in ordinary dry milk-foods might be explained on the assumption that the foods in question were manufactured with milk from which a portion of the cream had been removed, or else that the amount of whole milk employed was small in proportion to the other constituents used in the preparation of the product. Pure cow's milk contains on an average 13 per cent. of solid matter, of which nearly one-third is fat. Hence, the evaporation of pure *rich* cow's milk to dryness would result in a residue containing approximately 33 per cent. of fat. It is thus evident that a dry "milk-food" containing 8.0–8.5 per cent. of fat, if manufactured from whole milk rich in fat, must have considerable material other than milk added to it; indeed, the above figures would suggest in the finished product a mixture of approximately one-fourth whole milk solids and three-fourths of some other material, assuming the latter to be wholly free from fat.

We believe there is wisdom in the modern tendency in infant feeding to approach as closely as possible to mother's milk. Granting this, due weight must be given to the fat or cream which is such a conspicuous element in breast milk. To make good this deficiency by addition of carbohydrates of various kinds can hardly be expected

to give as satisfactory results as addition of fat, for fat is plainly an essential element in the nutrition of the infant as well as of the adult, and its place cannot be wholly taken by carbohydrates. It would be folly in infant feeding to attempt any positive statements on general principles as to how much fat or how much carbohydrate the infant should have. We can simply look to mother's milk, and, taking that for our standard, rest assured that in following nature's leading we cannot greatly err.

REPRINTED FROM

New York Medical Journal, July 18th, 1896.

Dietetic & Hygienic Gazette, October, 1895.

Dietetic & Hygienic Gazette, January, 1896.

FAIRCHILD BROS. & FOSTER,
NEW YORK.