THE RÔLE OF THE CARBOHYDRATES IN DIETETICS,

AND THE

CONSTITUTION AND USE OF INFANTS' FOODS.

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THE RÔLE OF THE CARBOHYDRATES IN DIETETICS, Etc.

General Considerations regarding Diet.

Diet Tables.

1. Full or ordinary diet, Royal Infirmary, Edinburgh.

Meat,	8	ounces (= $1\frac{1}{2}$ oz. water-free albumin).
Vegetables,	8	„
Bread,	16	„
Barley, rice, or peas,	$1\frac{1}{2}$	ounce.
Sugar,	$1\frac{1}{4}$	„
Salt,	$\frac{3}{4}$	„
Butter,	1	„

Porridge and milk if desired.

2. Public diet (Moleschott).

Proteids,	130	grams.
Fats,	84	„
Carbohydrates,	404	„
Salts,	30	„
Water,	2800	„

3. Diet of European armies.—Water-free food in ounces.

	English.	French.	Russian.	Austrian.
Albuminates,	3·86	4·33	4·02	3·73
Fats,	1·30	1·27	1·09	1·64
Carbohydrates,	17·43	18·04	19·62	17·0
Salts,	0·81	1·0	1·50	1·0

4. Sailor in British Navy.

Salt meat,	9	ounces.
or		
Fresh meat,	$4\frac{1}{2}$	„
Carbohydrates,	$26\frac{1}{2}$	„

5. Prisoners at hard work, and confined for more than three months;
   36 ounces of food daily. Butcher's meat forms only a small proportion of this, amounting to 16 ounces per week.

6. The diet of the Trappist monks is vegetarian, and consists daily of—

Bread, .	17½ ounces.	=	Proteids, . .	2·186 ounces.
Beer, .	17½ ,,		Fats . . .	0·35 ,,
Vegetable soup,	2 plates.		Carbohydrates,	15·08 ,,
Green vegetables,	1 plate.			

From these tables it is manifest that the chief element in all dietaries is the carbohydrate one, the proteids forming but a small proportion, the fats and salts holding a still lower place.

While proteids are of first importance in building up the active tissues, the carbohydrates form, through their combustion, the energy or heat-producing agencies, or are stored up as reserves of such.

Proteids are notoriously less easily digested than carbohydrates, and it is affirmed that vegetable proteids are even less digestible than animal proteids. It is a matter of common observation that, unless we take active exercise when living on a diet rich in animal food, we soon get out of sorts, and become bilious or dyspeptic. In all likelihood this is due to accumulation of many extractives in the body. Where do the most of the proteids come from which we consume in our food?

Looking at the percentage composition of flesh, we see how little proteid material it contains, and one can easily calculate the small quantity of nitrogenous matter which is obtained in consuming the ordinary amount of meat.

Composition of Flesh.

	Ox.	Fowl.
Water, ...	77·50	77·30
Solids, ...	22·50	22·7
Soluble albumin, . .	2·20	3·0
Insoluble albumin, .	17·50	16·5
Fat, etc., ...	2·30	3·2

It is obvious, therefore, that in ordinary diets the nitrogenous matters are chiefly of vegetable origin, and so are usually consumed along with the carbohydrates in the form of bread, farinaceous materials, or vegetables.

While a mixed diet in which animal food is present may be, and probably is, useful, we see that it is by no means absolutely necessary.

The proteids contained in farinaceous foods and vegetables are amply sufficient in most cases to replace the animal proteids, and I believe that when the organism becomes accustomed to the vegetable proteid there is little greater difficulty in digesting it than there is with the animal proteid. There could hardly be found stronger men than Scotch ploughmen of a century ago, and their staple food consisted of porridge and milk. The prisoner's diet of to-day would be much improved did it contain more of the quondam ploughman's food, and many would leave prison in better health than is the case at present. Native Indians eat scarcely anything but rice, to which a little butter (usually rancid) is added, and rice is almost the poorest in proteids of any farinaceous food which we have (7·40 per cent.).

It is usually stated that when a food stuff so rich in one element is used alone very large quantities of it must be consumed, so as to get a sufficiency of that element in which it is poorest. Theoretically this is true, but in practice it is seldom observed. The Chinese or Indian eats by no means an extravagant quantity of rice; in fact, we should be inclined to call it very moderate. Then we have always the extreme and historical examples (like Alexis St Martin in questions of digestion) of Cornaro, who lived healthily and well for fifty-eight years, or till he attained the age of 103, on 12 ounces of food, chiefly vegetable, and 14 ounces of light wine daily; or of the still more abstemious Thomas Wood, a miller of Belaricoy, who lived happily for nearly twenty years on a daily pudding made of a pound of flour with water, no other fluid being taken.

I have no intention of posing as an advocate of vegetarianism, though I think there is a very great deal to be said in its favour. Of course, we know well the oft-alleged assertion that, owing to the structure of the digestive tract in man, he is capable of digesting both animal and vegetable foods, and therefore ought to make use of both. The capacity for digesting both of these varieties implies, however, that each can be perfectly used up in the human economy. We know of many hardy races who are almost, if not entirely, vegetable eaters. Dr Parkes remarks that the meat eater and the man who lives on corn, peas, or rice are equally well nourished, and that the well-fed vegetable eater shows, when in training, no inferiority to the meat eater. Then, amongst animals, the largest and most powerful, either domestic or wild, are purely vegetable eaters,—as the horse, ox, elephant.

I think these facts are sufficient to show that perfect health may easily be enjoyed while animal food is excluded from the dietary; and at the same time they may serve to direct attention to one of the most important elements in a proper diet, viz., the *carbohydrates*. We have seen that they form the largest part in any scheme of dieting, and we remember that they form the staple food of young children and invalids. They thus merit, in my opinion, a greater regard than as yet they seem to have received from the clinician or physiologist.

Digestive troubles form the most potent factors in swelling the mortality tables of children dying under one year. This fact is more strikingly brought home to us when we recall that the mortality of children is greatest from the fourth to the sixth month, and this period corresponds to the time when "hand-feeding" is usually begun, with its dire results in too many cases.

Again, in towns this practice of artificial feeding of children is far more general than in country districts, and this is well shown in the Registrar-General's Returns. For instance, the death-rate per 1000 from diarrhœa in 1887 was, in rural districts 0·50; while in London it amounted to 0·90; and in the twenty-eight "great towns" together it formed 0·97. In 10,000 deaths amongst children in the city of Berlin it was found that 7646 had been artificially fed.

Apart from the question of infant mortality as the result of mismanaged feeding, there is the immense importance of this branch of dietetics in the many forms of indigestion and diseases of the alimentary organs in adults.

Statistics of hospitals and dispensaries prove that affections of the alimentary tract form by far the largest proportion of all diseases occurring during adult life, and these are only too frequently induced by unsuitability of food or irregularity in feeding.

In this paper I shall only deal with one branch of the carbo-hydrate group, viz., the digestion of starches (I have already in other papers treated of the digestion of sugars), though incidentally we may have to speak of sugars also.

Résumé of the Chemistry of Starch.

The chemical constitution of starch may be represented in its simplest form by $C_6H_{10}O_5$. More probably, however, it is a multiple of this, and n $(C_{12}H_{20}O_{10})$ would represent it more accurately, n being unknown, though probably never less than five or six.

When starch is heated by itself, or, as mucilage, if boiled with dilute acids, or when acted on by diastase, it becomes changed into an isomeric body—dextrin.

There are many varieties of dextrin. That which is formed earliest is termed soluble starch or amylodextrin. As dextrination proceeds erythrodextrin is formed, and still later the achroo-dextrins. If ebullition with acids be continued, or if diastase be allowed to act for a long enough time on the dextrin, it becomes hydrated and changed into maltose, which in its turn becomes converted into glucose ($C_6H_{12}O_6$) through the continued action of diastase or of dilute acids.

When a solution of iodine is added to starch, a deep blue colour is produced. Soluble starch in solution gives a violet colour with iodine. If dry, however, the colour produced is yellow, violet, or brown.

As the starch undergoes conversion this violet becomes a purplish-red and then a red colour with iodine, showing that the stage of erythrodextrin formation has been reached.

Still later this red colour becomes lighter, till at length no coloration results from adding iodine solution. This is the stage of the achroodextrins. Of these there are many varieties differing from each other in their rotatory and reducing powers. The first to be formed,—achroodextrin α,—can still by the action of diastase be changed into maltose and glucose, as happens with amylodextrin and erythrodextrin.

The formation of dextrins has been explained thus. The constitution of soluble starch is probably represented by the formula $C_{120}H_{200}O_{100}$. Under the influence of the diastase of malt it assimilates a molecule of water, and so forms a molecule of maltose, the rest going to form erythrodextrin α.

$$\underset{\text{(soluble starch)}}{C_{120}H_{200}O_{100}} + H_2O = \underset{\text{(maltose)}}{C_{12}H_{22}O_{11}} + \underset{\text{(erythrodextrin } \alpha\text{)}}{C_{108}H_{180}O_{90}}.$$

On further hydration another molecule of maltose is formed, and erythrodextrin β, which has a less molecular weight.

$$\underset{\text{(erythro. } \alpha\text{)}}{C_{108}H_{180}O_{90}} + H_2O = \underset{\text{(maltose)}}{C_{12}H_{22}O_{11}} + \underset{\text{(erythrodextrin } \beta\text{)}}{C_{96}H_{160}O_{80}}.$$

By a similar process achroodextrin results—

$$\underset{\text{(erythro. } \beta\text{)}}{C_{96}H_{160}O_{80}} + H_2O = \underset{\text{(maltose)}}{C_{12}H_{22}O_{11}} + \underset{\text{(achroodextrin)}}{C_{84}H_{140}O_{70}}.$$

There is a difference of opinion between chemists as regards the further changes which occur. The most recent and careful investigations seem to leave no doubt, however, but that the hydration process goes on till only maltose is left. Each of its molecules in turn takes up a molecule of water through the continued action of diastase or dilute acids, and splits up into two molecules of grape sugar—

$$\underset{\text{(maltose)}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{(grape sugar)}}{2\ C_6H_{12}O_6}.$$

Digestion of Starch.

Ptyalin is the ferment in the salivary secretion which converts the starch granules into achroodextrin, maltose and glucose. Through the continued action of this ferment maltose is slowly split up into glucose. The amylolytic action of saliva is destroyed by high temperatures, as by boiling; while at low temperatures conversion becomes slow, and ceases at 0° C. At the normal blood heat (38° C.) starch is converted by ptyalin very rapidly in an alkaline solution. It is said that small quantities of hydrochloric acid suspend and rapidly kill the ferment. On the other hand, it is affirmed that its action goes on in neutral as well as in slightly acid solutions. In strongly acid or alkaline solutions its action soon ceases.

The question as to the activity of the salivary ferment in acid solutions is of great importance as regards the digestion of starch in the stomach. If hydrochloric acid be poured out early in digestion, the alkalinity of the swallowed saliva will be soon neutralized, and the activity of the ptyalin must soon come to an end. It is almost certain, however, that the hydrochloric acid in the stomach combines at once with the proteids during the earlier stages of digestion, and so, no free acid remaining, saliva still continues its conversive action on starch. This condition lasts for a time varying from three-quarters to two hours. At the end of this period the proteids have combined with as much acid as they require, and now free hydrochloric acid appears in the gastric secretion. The conversion of starch in the stomach then ceases, as ptyalin is destroyed by the acidity of the gastric juice in full digestion. There are thus two periods in gastric digestion—(1), when saliva still acts; and (2), when pepsin is alone active.

What degree of acidity hinders or kills the ferment ptyalin? Do the various acids differ in their power of destroying ptyalin?

These questions seem to me of great importance. During the earlier stages of digestion, though no free hydrochloric acid is present, the gastric secretion is often acid from the presence of lactic, acetic, malic, or tartaric acids, or from acid salts, taken along with the food.

Does ptyalin still act during this period? If it only acts in alkaline or neutral solutions, then its action will be limited to the time during which food is being masticated and swallowed; or if the food be itself acid, its converting action ought to be entirely inhibited. In the stomach its action will only go on till the alkalinity of the saliva is fully neutralized.

In nearly all cases, therefore, ptyalin must be entirely destroyed before the contents of the stomach escape into the duodenum. Only in these cases where the acid has been so deficient that conversion of starch has gone on uninterruptedly in the stomach, can ptyalin escape destruction. Nor, indeed, is it necessary that ptyalin should be preserved in normal conditions, for soon after the contents of the stomach escape into the duodenum their acidity becomes neutralized, and they then encounter the pancreatic secretion, which is very much more powerful than the saliva in its diastatic action on starch, as it transforms it almost immediately into maltose and glucose. This converting ferment of the pancreas, amylopsin, can act on raw starch at the temperature of the body, giving rise to the production of several dextrins which have a reducing power on alkaline solutions of copper as well as maltose and glucose. The pancreatic secretion further changes maltose and dextrins into glucose. This hydration process is slow, however, and is much assisted by the action of the *succus entericus*.

The *succus entericus* has only a very slight action on starch (it is even denied that it possesses any), and it takes many hours' digestion with it even to produce a small amount of erythro-dextrin and soluble starch. The small intestine possesses, however, a powerful hydrolytic action on maltose, much more so than on soluble starch, dextrins, or even cane sugar. This property is chiefly resident in the agminated and solitary glands of the small intestine. The physiological actions of the pancreas and *succus entericus* are consequently mutually dependent. Starch under pancreatic proteolysis becomes changed for the most part into maltose and glucose. The former then encounters the intestinal secretion and undergoes hydration and splitting up to form glucose. In this way the whole of the starch is at length changed into glucose.

A starch-converting ferment is, however, widely diffused throughout the tissues of the body, and Magendie long ago showed that blood serum possesses this amylolytic power. It has also been recently shown that if solutions of starch be slowly injected into the tissues they are soon converted and entirely absorbed.

Digestion of Starch during Infancy.

Are the digestive processes of the young child materially different from those found in the adult? Can infants fully digest and absorb amylaceous matters?

This question has been carefully investigated, and it has been found that though starch can in very small amount be digested from the earliest period of life, yet it is a slow process. For the first two months of the child's life the amount of saliva secreted is very small, and we have all noticed how dry the mouth is in healthy infants. During the first month of the child's life the total secretion of mixed saliva is only about 1 c.c. in twenty minutes. The secretion rapidly increases after the first month: till at the third month the rate is about 1 c.c. in two minutes. Along with this scantiness in secretion of saliva, its proteolytic action is slow, and in a child seven days old, starch solution only showed a commencing conversion after it had been acted on for four minutes by the saliva. Because of this scanty secretion and slow action, many have thought that the salivary secretion in infants possessed no diastatic action on starch.

Ptyalin does not appear in the saliva to any marked extent till the sixth month; that is to say, till the eruption of teeth begins. At this time also saliva is secreted in great abundance, though there is a larger admixture of mucus, probably from the irritation, than at other times.

It is not, however, till nearly at the end of the child's first year that the amylolytic action of the saliva reaches its full amount and power. There is no essential difference between the gastric digestion of infants and adults.

The pancreatic secretion possesses no conversive action on starch during the first month of life. During the second month this power is developed, and is well marked at the third month. But, as with the salivary glands, so here: the full development of the diastatic action is not reached until the end of the child's first year.

At an early period of life, moreover, the number of glands in the intestinal canal is relatively small. As the child grows older, so does the number of glands increase. The development of the glandular system advances *pari passu* while the lymph vascular system decreases in importance.

THE CONSTITUTION AND USE OF INFANTS' FOODS.

Infants' or Invalids' Food.

We come now to consider foods designed for the special use of infants or invalids.

Condensed Milk.

This is by no means a starchy food, yet I may be pardoned for mentioning it, as it is undoubtedly by far the most universally used form of infants' food. It is easy to see why this is so, for owing to its small bulk, and consequent convenience in carriage, the length of time which it keeps, and the ease with which it can be made ready, its use is made general.

It is certainly for many children a good substitute for mother's or even for fresh cow's milk, and specially so for children during the first month or two after birth, with whom it nearly always seems to do well. But still this does not warrant us in recommending its general use, for many children assimilate with impunity food which is most deleterious to infants as a class.

This milk is prepared in two forms—

(1.) Simply condensed and unsweetened.

(2.) Condensed and with cane sugar added to preserve it.

The first consists in merely evaporating ordinary cow's milk down to one-third or one-fourth its original volume. In only too many cases, however, the milk has previously undergone a partial, or even an entire, skimming to remove the cream before it has been concentrated.

This forms a thick, syrupy, pale-yellow fluid, and merely requires the addition of water to restore it to its "original condition" (?) it is said. This preparation is not so largely used as the second, as, on account of there being no preservative added, it does not keep sweet for more than two or three days after the tin is opened. If kept longer than this, or in warm weather when organic fluids decompose rapidly, there are all the risks of giving the infant a fluid which is beginning to undergo fermentative changes, and we know how common a cause of infantile diarrhœa tainted cow's milk is during summer or autumn.

The sweetened variety is the one so universally used. It is a generally accepted fact that many infants fed on this variety rapidly put on fat. Many of these children are flabby and soon show signs of rickets. Gastric and intestinal catarrhs frequently occur in them, and it is rare to find that they have uninterrupted good health. My own experience agrees with the usual opinion that such feeding makes children less able to withstand the usual diseases of infancy, or renders the convalescence from them slow and unsatisfactory.

Of the large number of rickety children found in all large towns, a very great proportion occurs amongst those who have been brought up on artificial food, such as condensed milk. In rapidly growing children the need of nitrogen must be satisfied in order to obtain proper development; but while in cow's milk the proportion of nitrogen to carbon is as 1 to 12, in preserved milk it is 1 to 20. The large amount of carbon given in such food explains why there is such a rapid deposition of fat, but the needs of bone and muscle must remain unsatisfied by such a food.

I examined several specimens of condensed and sweetened milks as they were found in the market, and subjoin the figures found in a few.

1. This was found to contain 13·13 per cent. of milk sugar. I then estimated the amount of cane sugar present by the method described by Pavy, and found it present to 41·6 per cent.

2. In another specimen of condensed milk I found the reaction to be acid, and that it contained 11·7 per cent. lactose and 43 per cent. cane sugar.

3. Another was said to be partially peptonized and condensed. It contained 12·63 per cent. lactose, and 33·84 per cent. of a substance having a reducing action on Fehling's solution and which was probably maltose. It contained, likewise, dextrins and fat, but no unchanged starch.

The first two of these preparations contain, therefore, a very large amount—nearly one-half of the total constituents—of a substance so difficult of absorption as cane sugar. This improper food is also increased in amount as the child grows older, not only by lessening the dilution of the milk but by giving him more of it, and thus the risks of this sugary food increase *pari passu* with the age of the infant.

In spite, therefore, of the general use of such sweetened condensed milks, I have no hesitation in stating that their use constitutes a form of injudicious feeding. The proportions of the food constituents are so altered that it has little resemblance to ordinary breast milk. Simple condensed and unsweetened milk is not in itself to be condemned, though certainly far inferior to fresh cow's milk, for the relative proportion of the constituents remain pretty much as they were originally on again diluting the milk. The constant use of the variety sweetened with cane sugar is, however, to be strongly deprecated.

It is a common practice amongst the poor to add starchy materials—as corn-flour, arrow-root, pounded biscuit, bread, etc.—to the milk which is given to the child. This is done with the idea of thickening the milk and making it thus more nutritious, for it is a popular idea that cow's milk is in itself not a sufficient food. They forget, meanwhile, that if the child were fed from the breast it would receive no other added food.

The physiological processes in the infant show that starchy matters must be very imperfectly digested by it, owing to the extreme feebleness and the scantiness of secretion of the diastatic ferments at an early period of life. All authorities agree in stating that farinaceous materials are quite unadapted and hurtful to the young child.

The only carbohydrate which a naturally-fed child receives is sugar of milk. There is no substance in milk which in the least corresponds to starch. It is only at the sixth month that the diastatic ferments of the saliva and pancreas are secreted to any extent, and certainly no pure starchy food ought to be given before this age. The full action of the saliva and pancreatic secretions on starch is not attained till the end of the first year, and it is only then that we may allow ordinary farinaceous food, as rice, corn-flour, etc., to be given. If we permit the use of such food before this age, then assuredly the starch should be predigested. By this I mean that unchanged starch must be rigidly excluded from the dietary and only given in a readily assimilable form, as after partial or complete conversion into dextrins, maltose, and glucose. I have already shown that glucose and some dextrins are directly absorbed, while maltose is not so, but requires to be changed into glucose first. Starch should be wholly converted into dextrins and dextrose when added to milk for infants of from five to six months.

At an early age it is sometimes found to be advantageous to add a carbohydrate to the dietary when the child is not thriving on milk alone, or in those cases where cow's milk sets into too firm a curd even when diluted with water. This firm curd is not well acted on by the gastric juice, and is rejected by vomiting. When a farinaceous material is added, however, the density of the curd is lessened, and so its digestion is rendered easier. In such conditions only the easily assimilated carbohydrates should be used, and I would recommend dextrins and dextrose, which, being easily absorbed, afford small opportunity for fermentative changes to occur.

As the diastatic power of the saliva and pancreatic secretions increases, we ought gradually to lessen the degree of starch conversion so as to stimulate more the secretion of these ferments. Thus, after the age of six months, I would only partially convert the starch, so giving a mixture of dextrins, maltose, and glucose. As the child grows older the degree of conversion ought to be still further gradually lessened, thus reducing the amount of glucose, while the quantities of dextrins (of lower variety) and maltose are increased relatively, till, at the end of the first year, we may allow almost natural well-cooked starchy foods to be given. To corroborate this, it has been shown by analysis that as lactation proceeds the amount of albumin in human milk diminishes, while the amount of carbohydrate increases, the amount of fat remaining the same. This goes to prove that as development proceeds the need for nitrogen becomes less, while the necessity for carbon increases.

This leads us, therefore, to the consideration of the so-called "infants' food." The food which is suitable for the young child is unsuitable for the same child at a later period, and so in order to be able to direct the dietary of the infant we must know of what these foods are composed.

Many different preparations are sold to the public under the name of "babies'" or "infants' food." Some, through their own merit, but more through judicious or persistent advertising, have become widely known and largely employed as additions to, or substitutes for, cow's milk.

The foods in themselves may be good enough, but may be unsuited to the age or condition of the children to whom they are given. The infant may thrive on a certain food for a time, but afterwards begins to fall off, even though it is taking the same food readily. If so, there must be some dietetic error, and we will probably find that it is in the character of the artificial food. This, though it nourished the infant well enough at an earlier period, does not form a sufficiently nourishing food for the same child when older.

Again, if we continue to give predigested food for too long a time, the secretions of the alimentary canal lose their distinctive digestive properties to a large extent through disuse of the glands. Thus on changing the food to one not previously digested, rapid emaciation follows, because the digestive secretory glands, having been out of action for some time, require an interval during which to regain their functions.

The constitution of some of these foods we know, but of many the nature of the ingredients is kept secret. In medicine anything which savours of quackery is eschewed. Why should it not be so likewise in dietetics, especially when they concern infancy? The whole after-life may be made or marred by the nature of the food partaken of during the active development of the child.

In all foods designed for the use of infants we must have the four elementary principles—proteids, fats, carbohydrates, and mineral matters. These must be combined in certain relative proportions so that the child may get a sufficiency of each and yet not an excess of any one. Too small or too great a relative amount of any leads ultimately to ill-health. In the first case some of the tissues are starved, while in the second all cannot be absorbed, and so intestinal irritation and general ill-health result.

It is, however, to the carbohydrate constituent of these foods that I desire now to devote attention, as this forms by far their most important element, and, as I have pointed out, requires the greatest care in administration.

Examination of Infants' Foods.

In most of the analyses of these foods the results refer to them as they occur in commerce, and not to the food as it exists after being prepared for use. These two analyses are very different in many cases. My investigations were made in order to determine in what condition the starch was after the food had undergone the process of cooking.

In preparing these for examination I followed the directions given with each food, only instead of using milk as the menstruum (which is sometimes recommended), I used ordinary water.

I generally made a 5 per cent. solution of the food, but when this gave too thick a mucilage I reduced it to a 2 or even to a 1 per cent. solution. Having allowed it to cool, I then tested the mixture for the presence of unchanged or soluble starch, erythrodextrin, achroodextrins, or sugar. I have named all those matters which have a reducing effect on Fehling's solution for brevity "glucose," but which may be glucose, levulose, maltose, lactose, or reducing dextrins. In each case I have calculated them as dextrose.

A definite amount of the solution was then heated on the water-bath for two hours at 140° F., five minims of a dilute solution (1 in 10) of sulphuric acid having previously been added to it. By this proceeding any cane sugar present in the food underwent inversion. This solution was again allowed to cool, any loss from evaporation made up, filtered, the condition of the starch again examined, and the amount of reducing substance again estimated.

In those cases where malt or malt extract was supposed to be present, instead of boiling (which would have destroyed the diastase) I simply warmed the solution, and having set it aside in a warm place for half an hour, examined the condition of the starch and estimated the "glucose" in it.

For obvious reasons I have refrained from mentioning the foods by name.

1. *A Milk Food* (N. M. F.).—This food is in the form of a yellow powder, extremely difficult to mix with cold water, and when so giving a muddy solution, having a faintly acid reaction. It has a very sweet taste, resembling that of ground biscuit.

The directions bear that it should be mixed with cold water and then boiled for a few minutes with continuous stirring.

Having made according to the directions a 2 per cent. solution of—

(1.) Boiled food, I found that it contained unchanged starch, soluble starch, some erythrodextrin, and 4·5 per cent. of glucose.

(2.) Having acidified and heated the solution for two hours, it then contained much unchanged starch, erythrodextrin in large amount, and glucose to 38·5 per cent. Lest there should have been malt or malt extract in this food, and which the boiling would have destroyed, I prepared a solution but only heated it to 100° F.

(3.) Solution only heated, not boiled—unchanged starch, trace of erythrodextrin and glucose, 6·65 per cent.

(4.) This solution, kept hot for thirty minutes, gave similar results.

(5.) A cold extract of the milk shows the presence of unchanged starch, traces of erythrodextrin and glucose 4·35 per cent.

This food clearly contains a large amount of cane sugar (34 per cent.), which must, by the method of preparation, be administered as such. The acidity was too feeble and the heat insufficient to have converted entirely the starch, except perhaps into some early formed dextrins; nor did there appear to be, after boiling, any dextrins present which might have been converted more readily. We must conclude, therefore, that this food contains much unchanged starch and cane sugar.

2. *A Soluble Food for Infants* (C. F.).—This is in the form of a very fine light yellow powder, freely soluble in water, and having a neutral reaction. It is said that this food is partially predigested by pancreatinine.

Directions.—The food is to be dissolved in a definite amount of cold water; then it is to be gradually added to an equal amount of boiling water, stirred till it boils, and boiled for two minutes.

Having made a 2 per cent. solution of—

(1.) Boiled food, it contained unchanged starch only, and glucose 20 per cent.

(2.) Acidified and heated at 140° F. for two hours. Unchanged starch and soluble starch, erythrodextrin in large amount; glucose now 23 per cent.

To see if the pancreatic ferment were active, or if invertible sugar were present, I prepared a solution, but did not boil it.

(3.) Solution made with hot water (not boiled), and examined at once, showed only unchanged starch; glucose 18·5 per cent.

(4.) Same solution kept warm (100° F.) for thirty minutes, showed unchanged starch, small amount of erythrodextrin, and glucose increased to 25·6 per cent.

(5.) A cold extract shows unchanged starch, erythrodextrin in traces, and glucose.

This food contains, therefore, only a very small amount of invertible substance, but the pancreatic ferment appears to be still active, though by following the directions the full advantage of this is not obtained. When merely heated for thirty minutes we get 25·6 per cent of glucose, but when boiled it forms only 20 per cent. This food would thus yield a more assimilable product if it were simply heated and not boiled. The starch is either unchanged or present as soluble starch when made according to the directions, but by heating it for long a large amount becomes dextrinized. Owing to the presence of the dried milk, however, this cannot be done, for then the pancreatic ferment would act for too long a time, and render it bitter. Thus the presence of milk in this food does not allow of us obtaining the full advantage of the amylopsin, and, besides this, the milk is predigested, and this is unnecessary in a food designed generally for the use of infants. This food would be valuable in acute diseases.

3. *A Non-Farinaceous Food* (M. F.).—This is in the form of a yellow powder possessing a sweet malt taste. It dissolves in water, giving a muddy yellow solution, and possessing a neutral reaction.

It is directed to be prepared by dissolving the food in cold water, then adding milk and water, and heating gently.

Having made a 2 per cent. solution, I examined it.

(1.) Prepared by dissolving in warm water. There is no unchanged starch present. No coloration results from the addition of iodine, so that any starch originally present has been converted into achroodextrins, maltose, or glucose. Glucose forms 29·8 per cent. of the food.

(2.) When acidified and heated for two hours, glucose forms 30·4 per cent. This is almost exactly the same as before, and so this food contains no invertible substance.

(3.) When heated alone for thirty minutes the same results were obtained.

The amount of reducing substance is the same after simply dissolving the powder as after heating with the addition of an acid. There is thus no cane sugar or other easily invertible substance present. The slight increase in the amount of glucose is probably due to conversion of some non-reducing dextrins into those capable of reducing copper from its solution, through the prolonged action of heat. Any starch which was originally present has been during manufacture converted into achroodextrins, maltose, or glucose.

This food contains, therefore, carbohydrates in their most easily assimilable condition.

4. *The same, with Desiccated Milk added* (M. L. G.).—This is in the form of a brownish-yellow powder having a sweetish taste of malt. It dissolves in cold water, forming a turbid fluid, and has an alkaline reaction.

It is prepared by dissolving in warm water. A 2 per cent. solution was made with warm water.

(1.) Solution made by heating only. Small amount of erythro-dextrin present. Glucose forms 32·7 per cent.

(2.) After being acidified and heated for two hours, it gives no reaction with a solution of iodine. Glucose forms 33·6 per cent.

This is almost exactly the same as before inversion. There is, therefore, only a trace of invertible substance present, or rather, and more probably, convertible substance, for the erythodextrins have become achroodextrins and reducing dextrins, so increasing the glucose nearly 1 per cent.

This food closely resembles the preceding in its composition, containing in addition desiccated milk. The carbohydrates are all in a very easily assimilable condition.

5. *A Pancreatized Food* (B. F.).—This is a dry white powder, resembling wheaten flour.

In preparing it for the use of infants, we are directed to mix it into a paste with one-third cold milk, then to add two-thirds boiling milk or milk and water, and set it aside in a warm place. In fifteen minutes it will have been sufficiently digested, and should then be slowly heated till it boils, when it is ready for use.

(1.) Mixed with cold water it has a slightly alkaline reaction, gives the starch reaction with iodine, and shows a trace of erythro-dextrin. It causes no reduction when boiled with Fehling's solution.

(2.) A 2 per cent. solution made with hot water, and examined at once, shows starch abundantly; erythrodextrin in greater amount than when made with cold water. Glucose is present to 7·8 per cent.

(3.) Prepared according to the directions; kept warm for a quarter of an hour, and then boiled. Starch reaction is not so marked; soluble starch and erythrodextrin in much larger amounts, and glucose forms 17·2 per cent.

(4.) A solution prepared according to the directions and heated, after being acidified, for two hours, shows only a very small amount of starch to be present. Much erythrodextrin is present, and glucose 13·9 per cent.

After this prolonged heating, the amount of reducing material has diminished. I do not know how to account for this, unless the pancreatic ferment has split up the products of digestion during the lengthened time during which it has acted. I repeated this and similar experiments several times, but always with the same result. This would seem to prove that there is a ferment, as has already been described, in the pancreas which is destructive to grape sugar.

This food contains, therefore, in its original state no substances which have a reducing action. It has undergone no previous treatment with malt. During its preparation, however, the pancreatic ferment which it contains acts on the starch, and in this way we have a large amount of dextrin and glucose formed, though, even after all, there is yet a small amount of unchanged starch left unacted on. The food seems to consist of flour chiefly, mixed with some pancreatic ferment. When milk is used in the preparation of this food it also, of necessity, will undergo digestion by the same ferment.

6. *A Food designed for the use of Infants during the first Three Months.*—This occurs as a gritty yellow powder having a slight cheesy smell, and with a sweet milky taste. It leaves a saline sensation in the mouth.

It is prepared by dissolving to a smooth paste in hot water, then adding a sufficiency of hot water.

(1.) Mixed with cold water it gives no reaction with iodine, and contains 34·7 per cent. of reducing sugar (glucose).

(2.) Made according to the directions, there is no change from the preceding.

(3.) Made with warm water and kept at 38° C. for thirty minutes, still same results.

(4.) Heated on water bath for two hours after acidification, the sugar has increased to 44·6 per cent.

This food contains, therefore, no unchanged or soluble starch, or even dextrins capable of higher transformation. Nor does it contain erythrodextrin. It seems to be what is affirmed, dried cow's milk from which has been abstracted the excess of casein; while cream, soluble albumin, and milk sugar have been added, to make it resemble ordinary mother's milk. The increase in the amount of sugar seen after heating with acid is probably due to the splitting up of lactose into glucose and galactose.

7. *A Food for Infants up to their Seventh Month.*—This is also in the form of a fine yellow gritty powder with sweet milky taste. It also leaves a saline taste in the mouth. It possesses a faint odour of cheese and malt

It is prepared by mixing with hot water and then adding sufficiency of hot or boiling water.

(1.) A cold extract gives no reaction for starch. It contains 36·2 per cent. of sugar (as glucose).

(2.) Prepared according to the directions, the constituents remain in the same proportion.

(3.) Prepared with warm water, and kept for thirty minutes at 38° C., the sugar has increased to 39·05 per cent.

(4.) Heated on water bath for two hours after acidification, the sugar now amounts to 39·65 per cent.

There is no starch of any kind present, but only dextrins and sugar. There is, however, some malt present, as the amount of sugar has increased during the period of simple heating. Some of the lower non-reducing dextrins have been changed into higher and reducing dextrins or into sugar through the action of this malt. This food thus resembles the preceding, except that it possesses originally more sugar, dextrins, and malt.

8. *A Malted Food* (A. H. F.)—This appears as a cream-coloured powder, having a sweet taste of flour and malt.

It is prepared by adding boiling milk and water to the food, which has previously been mixed to a paste with cold water, and to which cane sugar has been added.

(1.) Mixed with cold water it shows the presence of unchanged starch, but no soluble starch, and contains 10·85 per cent. of reducing substance.

(2.) Made according to directions, and examined at once. Unchanged starch is present along with erythrodextrin, and reducing substances form 12·4 per cent.

(3.) Prepared as directed, and kept warm for thirty minutes. Trace of unchanged starch. No soluble starch, or mere trace. Erythrodextrin in large amount, along with achroodextrins. Reducing substances form 12·85 per cent.

(4.) Heated for two hours on water bath after acidification. Shows the presence of trace of unchanged starch. Soluble starch. Much erythrodextrin. Reducing substances, 14 per cent.

These three latter preparations are intended to form a continuous diet for the infant from birth up to the end of the first year.

The first (No. 6) consists merely of ordinary cow's milk so treated as to resemble closely human milk. It is then sterilized and dried in vacuo.

The second (No. 7) consists in an addition to the first of maltose, dextrins and malt, together with soluble salts.

While the third (No. 8) consists of starch which has undergone a partial conversion through the action of malt. During the process of preparation the degree of conversion is still further advanced.

The *first food* is designed for infants up to three months of age the *second* from three to seven months, and the *third* (along with ordinary cow's milk) from this age onwards.

9. *A Malt Food for Infants* (S. M. F.).—This is a fine cream-coloured powder, closely resembling and having the taste of heated flour. Directions for preparing the food: It is to be mixed with cold milk, or milk and water, into a thin paste. Then boiling milk or milk and water is to be added till the food thickens (at 140° F.). It then rapidly becomes fluid, and is ready for use.

(1.) When mixed with cold water its reaction is faintly alkaline, and it shows the presence of unchanged starch, but no sugar.

(2.) A 2 per cent. solution prepared according to the directions, but with water only. Starch is present in small amount. Much erythrodextrin and achroodextrin. Glucose 9·25 per cent.

(3.) Part of this solution kept at 100° F. for thirty minutes. Starch in very small amount. Much soluble starch and erythrodextrin. Glucose 11·1 per cent.

(4.) A solution acidified and heated at 140° F. for two hours shows only a trace of unchanged and soluble starch, erythrodextrin in very large amount, as also achroodextrin. Glucose amounts to 15·6 per cent.

(5.) A solution prepared by adding the food to tepid water, and keeping it at 80° F. for thirty minutes, showed very little unchanged or soluble starch, much erythro- and achroodextrin. Glucose forms 5·3 per cent.

This is clearly one of the malt foods, consisting of flour and malt. Under the influence of heat and solution, the latter acts on the former to cause its conversion into dextrins, maltose, and glucose. We see that the conversion is more complete the longer the mixture is kept warm. If, however, the temperature is never raised high (as in 5), the diastase of the malt converts the starch merely into dextrins, and but little reaches the condition of sugar. If kept for long, however, even at this temperature, all the starch ultimately becomes changed into maltose and glucose.

10. *A Self-Digesting Whole-Meal Food.*—This is a fine yellowish powder with brown particles in it, and possessing a strong taste of malt. It is cooked in exactly the same way as the preceding.

(1.) Mixed with cold water, its reaction is faintly alkaline, and it consists solely of unchanged starch with the merest trace of sugar.

(2.) Prepared according to directions. Much erythrodextrin, achroodextrin, soluble starch, and unchanged starch. Reducing substances form 7·35 per cent.

(3.) When kept at 120° F. for thirty minutes the erythro- and achroodextrins have increased at the expense of the starches, and reducing substances form 8·3 per cent.

(4.) Acidified and heated for two hours. Still more dextrins present, and reducing substances 11 per cent.

This food does not differ from the preceding except that apparently whole meal has been used instead of flour.

11. *A Malted Food* (H. M. F.).—This is a granular, gritty yellow powder, having a sweet milky taste.

It is prepared simply by dissolving in hot water. The amount of the powder used is regulated by the age and condition of the child.

(1.) Five per cent. solution made with warm water. Alkaline reaction. There is no unchanged or soluble starch, and no erythrodextrin. No precipitate is formed on adding acetic acid. Glucose amounts to 23·25 per cent. of the food.

(2.) Part of this solution kept at 100° F. for thirty minutes showed an increase of the glucose to 25 per cent.

(3.) Acidified and heated for two hours. Glucose forms 31·25 per cent.

This preparation is said to consist of desiccated cows' milk, malted flour, and alkaline carbonates to neutralize the acidity of the milk.

It contains no starch or early-formed dextrins. It has been almost completely malted already. The length of time it is heated by itself increases but little the amount of sugar. The increase in reducing substance by the prolonged heating with acidification is not likely due to added cane sugar, but most probably to the more complete conversion of some of the higher dextrins (achroodextrins) into reducing dextrins and sugars.

This preparation contains, therefore, dextrins, maltose, glucose, albuminous materials, and mineral salts.

12. *A Patent Cooked Food for Infants* (R. F.)—This is a cream-coloured powder, looking and tasting like heated flour. Directions: Mix the food with water or milk to form a cream; add hot water or milk, "stirring briskly while boiling." It is then ready.

(1.) Prepared with cold water it has a faint acidity, and consists of unchanged starch with no sugar.

(2.) Prepared according to directions, but not boiled, only kept at 120° F. for thirty minutes. It gives only unchanged starch reaction, along with the faintest trace of reducing sugar.

(3.) Prepared by boiling—starch alone is present; no sugar. Even if kept for thirty minutes at 120°, no further change results.

(4.) Acidified and heated at 140° F. for two hours, a large amount of erythrodextrin is present, along with soluble and unchanged starch. Glucose forms 5·4 per cent. of the food.

This food contains apparently only flour; and if prepared according to the directions, we only get a paste containing no dextrins nor sugar. At best the starch is only present in its soluble form. Prolonged heating after acidification converts a good deal of the starch into dextrins and into a small amount of sugar.

13. *A Farinaceous Food* (F. N.)—This appears in the form of a light cream-coloured powder, with a taste of heated flour. Directions: Mix the food with cold water to form a thin paste; add boiling water, and boil gently for five or seven minutes. Then milk and sugar are added and it is ready.

(1.) Mixed with cold water it has a neutral reaction, contains unchanged starch and no sugar.

(2.) A 2 per cent. solution made as directed, but not raised above a temperature of 140° F., and kept at this for half an hour, shows only the presence of unchanged starch. Glucose forms 1·65 per cent.

(3.) Prepared according to the directions, no sugar or dextrins, but only unchanged starch.

(4.) Part of this solution (No. 3) kept at 100° F. for thirty minutes shows a trace of sugar.

(5.) Acidified and heated for two hours. Nearly all the starch has been converted, only a trace being left unchanged. Erythrodextrin is present in large amount. Glucose forms 6·88 per cent. of the food.

This food is very similar to the last. Prepared in its usual way, the starch remains almost unchanged. If heated for long, however, a large amount of conversion takes place, and more especially if rendered acid.

14. *Another Farinaceous Food* (F. H.)—This is a fine powder, closely resembling ordinary flour. It is prepared by mixing with a little cold water. Boiling water is then added, and it is boiled for eight minutes. Milk and sugar are added to make it agreeable.

(1.) Mixed with cold water it has a neutral reaction; contains no sugar or dextrin, but only unchanged starch.

(2.) A solution made with warm water and kept at 140° F. for thirty minutes, but not boiled, shows the presence of dextrin in small amount, much unchanged starch, and glucose forms 2·27 per cent.

(3.) Prepared as directed, only unchanged starch is present; no sugar or dextrins.

(4.) Boiled and kept warm for thirty minutes, gives results similar to No. 3.

(5.) Acidified and heated for two hours, shows very little unchanged starch, much erythrodextrin and achroodextrin. Glucose forms 6·25 per cent. of the food.

This food also closely resembles the two preceding. If made as indicated we get only a flour paste, but if heated for long a large amount of conversion results.

15. *Another Farinaceous Food* (F. N. H.)—This appears as a coarse white powder, with which are mixed small hard brown scales like bran. For infants' use it is prepared by pouring equal parts of boiling milk and water over the food which has previously been slightly moistened. It then is boiled for five minutes.

(1.) Mixed with cold water it has a faintly acid reaction, and shows only the presence of unchanged starch.

(2.) A solution prepared with hot water and kept at 120° F. for thirty minutes shows much unchanged starch; small amounts of dextrins. Glucose forms 5·2 per cent.

(3.) Prepared according to the instructions, only unchanged starch; no sugar or dextrins.

(4.) Part of the latter mixture heated for thirty minutes shows a trace of sugar.

(5.) Acidified and heated for two hours, much unchanged and soluble starch; erythrodextrin in small amount; glucose 2·32 per cent. of the food.

It is evident that the boiling which the food is directed to have destroys the small amount of power of the converting ferment which it seems to possess. When simply made with warm water and kept warm, it develops 5·2 per cent. of glucose, whereas if boiled there is none.

General Conclusions regarding Infants' Foods.

We gather from the preceding analyses of the principal varieties of infants' foods the following:—

1. Most of these consist of wheaten flour mixed with malt or extract of malt. The latter is supposed to act on the starch of the flour during the process of cooking, and by the diastase which it contains to convert the starch into maltose and glucose.

I have shown, however, that in several of these varieties, if prepared according to the directions accompanying each, only a very small conversion of starch occurs. A temperature of 140°-150° F. is most suitable for the action of diastase; while if carried to 212° F. the ferment is killed or its action arrested. Now, several of these foods are prepared by adding boiling milk or water, and then boiling for from five to ten minutes. Such treatment effectually prevents the starch from undergoing any conversion, or soon brings to an end any that is going on already. I have shown that if some of these foods be prepared by adding warm water, and be then kept warm for half an hour, the temperature not being allowed to rise much above 150° F., part of the starch undergoes conversion, and we then find dextrin, maltose, and glucose, with or without unchanged starch, depending on the time allowed and on the strength of the ferment.

Some of the foods composed of flour and malt are directed to be prepared thus, and with these no fault can be found. Those, however, which are directed to be boiled, I have no hesitation in saying, are quite unsuitable as foods for young infants. Not that the food is in itself bad, but owing to the mode of preparation which renders it so. If properly cooked, some of these would make fairly good foods.

Those containing ground malt should always be used in preference to those which contain the extract, as the former is much more active in its converting power.

It is to the mixtures of malt and flour that I look to the greatest improvement in the feeding of infants. By varying the time during which such mixtures are heated, we may convert the starch to any degree we desire, and so make it suitable for the child at different ages or according to its condition of health. We may either wholly convert the starch by prolonged heating, so making it suitable as a food in addition to milk for young infants; or the conversion may be only partial, leaving still soluble starch, dextrins, and maltose. As the child grows older the amount of conversion is proportionally lessened, till when it has arrived at a suitable age or condition unchanged starch may be given alone.

In a few of these foods cane sugar is also added; but this is an addition to infants' or invalids' food which I have elsewhere sufficiently condemned.

2. Instead of malt, some contain the pancreatic ferments. These act both on the starch and on the milk with which the foods are prepared, and so both are predigested.

Such foods must be most valuable in conditions of great debility, inanition, or exhaustion in infants or invalids. In an ordinary food for children, however, we do not wish to digest the milk, which is the natural food of the child, and which usually can be digested well enough. Proteids are generally well digested by infants, and we take advantage of this to feed them on meat infusions when there is great debility. As a general rule, therefore, we do not desire to predigest the proteids of milk, but only the carbohydrate element which the infant cannot properly, or only partially, digest. It has been shown that kittens fed on fully predigested milk did not, for a time, thrive so well when this was replaced by only partially predigested milk as their brothers and sisters who were fed on ordinary milk. The use of predigested foods lessens the activity of the glands which ought to secrete the digestive fluids. We ought not, therefore, to give artificially digested food for a longer time than is absolutely necessary.

3. In some of the foods the starch has been converted previously through the action of the diastase of malt. In these we find no unchanged starch, or at most mere traces of it; erythrodextrins and achroodextrins are found in varying amount; while maltose and glucose occur usually in large amount.

Nearly all of these are made from flour, and so contain, besides, the vegetable albumins and mineral matters. In some foods an alkaline carbonate is added in order to neutralize the acidity of ordinary cow's milk.

Such foods as these are very easily absorbed. The starch is almost wholly changed into easily absorbable dextrins and glucose, and so they require little or no digestion. This is manifestly of the greatest importance to the child, in whom the power of digesting carbohydrates is at the minimum.

4. Combinations of dextrins and starch are often met with, and are highly vaunted as valuable foods for infants. Such foods consist simply of flour which has been subjected to a high temperature, and has thus been baked. The starch during this heating becomes changed into soluble dextrins. If the flour has been carefully heated, and for a long enough time, the starch becomes wholly dextrinized. In the usual foods, however, such treatment has rarely been carried sufficiently far; thus only a part, and usually a small part, of the starch has undergone conversion even into the early formed or low dextrins. They contain usually much unchanged starch, along with the albuminous constituents and salts of the grain. Domestically this is known as the "flour-ball," and is prepared by boiling flour in a cloth for about twenty-four hours. It then forms a hard ball, which, after the translucent outside skin has been pared off, consists of a dense white substance, made up of dextrinized starch. This is then ground down and mixed with milk for the infant's use. Used in this manner it forms an easily assimilated carbohydrate, and, acting as a mechanical diluent, helps to prevent the milk from coagulating in large or firm clots in the stomach.

If these dextrinized foods are thoroughly well prepared they form valuable additions to the milk. If imperfectly dextrinized, however, the large amount of unchanged starch which is also given forms a great drawback to their use as safe articles of diet.

5. Many preparations sold as food for infants consist simply of flour or unchanged starchy matter.

Such foods ought never to be given, as only a small part can be digested by the infant. We find that many of these, besides, are very coarsely prepared, and show, when examined by the microscope, the presence of husks, spiculæ, etc., which must prove most irritating to the delicate intestinal mucous membrane, and which form a sufficient cause in many cases for the diarrhœa which ensues after such food is administered.

Owing to the relatively small number of glands in the intestinal tract in the young child, and to the immaturity of those which are present, the infant is unable to assimilate carbohydrates which require extensive change.

As the child grows older greater liberties may be taken with his digestion; but at an early period of his life it is culpable ignorance to tamper with the delicate machinery of digestion by giving any or the first food which may present itself to the parents or to the seller.

It seems to me that the general and unrestricted sale of such preparations as food for infants ought to be prohibited; or that, at least, they should only be sold by qualified chemists who would first inquire as to the age and condition of the child, and who would thus know whether the food were suitable or not. A still safer plan would be that none of these foods should be supplied unless prescribed by a medical practitioner,—in fact, dispensed in the usual manner in which drugs are sold. In order to do this, however, the method of manufacture and composition of each food, both before and after being cooked, would require to be made public and printed on each packet.

It is the wholesale vending, nay, the intrusion, of such foods on people that renders their use so general. It is a fact that so soon as a birth is advertised in the newspapers, many of the manufacturers of these foods send samples of their preparations to the parents, and, of course, each is accompanied by its own laudatory literature. The parents, knowing little regarding the proper feeding of their child, select one which they think is best, and so, unguided by experience and ignorant of physiological processes, they usually choose that which is most highly vaunted or is accompanied by portraits of the fattest babies reared on such food.

It is on account of the incalculable harm which is thus done—unwittingly in many cases—to the infantile population, that I would put the sale of such foods under a restriction. For this purpose a special clause might be introduced into the "Sale of Foods and Drugs Act," so as to make the indiscriminate sale of infants' foods penal.

Almost all the forms of infants' foods are directed to be made with milk or with a mixture of milk and water, except those which already contain desiccated milk.

In those which contain malt the starch becomes converted in large part during the preparation of the food. Now it has been shown that if malt be added to milk, and if this mixture be kept at 100° F. for some time, the casein of the milk undergoes such a change that it becomes uncoagulable by acids. I have verified this, and find that when acetic acid is added to milk which has been heated with malt no curdling takes place. This fact must be of great importance as regards the digestion of milk, for one great cause of indigestion is the formation of large clots of milk in the stomach. In foods containing malt the milk is also acted on during the process of cooking, and so rendered uncoagulable by the acid of the stomach. Might this not prove serviceable in the treatment of some forms of indigestion following the use of cow's milk? Instead of mixing the milk with any starchy food, would it not be preferable to keep it in contact with a solution of malt for some time so as to prevent the formation of dense coagula in the stomach?

Such foods containing malt, when the cooking causes an almost complete conversion of starch, or those which are already entirely converted, when added to diluted cow's milk, and with a little cream added (for nearly all these foods are deficient in fat, and the dilution of the milk reduces the percentage of fat much too far), make, in my opinion, the most suitable substitute for mother's milk, or for infants with whom ordinary cow's milk does not agree, or who are not thriving on it.

Not only are these foods good as adjuvants to milk, but they are sometimes the only food which the child can digest. After once that fermentative changes have taken place in the gastric and intestinal contents, with consequent vomiting and diarrhœa, the bacteria which have caused these remain, and cause milk to become acid as soon almost as it has been taken. Under such circumstances the use of milk must be stopped, and we have then recourse to such foods as the above, along with infusions of meat, as veal or chicken broth.

At a later date also they are of great value, when we are beginning to add other food materials to the milk. What better can we begin with than some of the easily digested carbohydrates?

It would be improper in me to specify by name the particular foods which I would recommend in feeding infants of various ages. After what I have said, however, there can be little difficulty in choosing the particular food for the particular age and condition of the child. I have shown what I consider to be the most easily assimilated forms of the carbohydrate group, and from the analyses of the carbohydrate constituents of the most widely-known foods for infants now on the market which I have given, it will be easy to select those which would form desirable additions to, or substitutes for, a purely milk diet.

What I have stated regarding the kind of carbohydrate food which may be given to the infant applies, and in some cases with even greater force, to the dyspeptic and invalid, or during senescence, when the digestive organs are feeble and assimilation is less active than formerly.

In such diseases as chronic gastric catarrh, dilatation of stomach with concomitant atrophy of the gastric glands, acid dyspepsia, cancer of stomach, congestion of the gastric and intestinal mucous membrane from heart or lung disease, I would forbid the use of ordinary farinaceous food, unless in very small amount; while I would advocate the use of partially or completely converted starch. In ascites or dropsy such food would act most beneficially and even therapeutically, for glucose and even dextrins form powerful diuretics, and act without raising the blood pressure.

In many febrile conditions the amylolytic action of the salivary and pancreatic secretions is greatly lessened, and only harm can be done by the administration of ordinary starchy foods; whereas if predigested they act as valuable and easily assimilated foods. Again, in those cases where there is great deficiency of hydrochloric acid in the gastric juice, as, for example, in anæmia, simple and pernicious, cancer of the stomach, etc., where proteid matters are not digested well, starchy food ought to bulk largely in the diet, as the amylolytic action of the saliva continues for long in the stomach, there being little or no acidity to cause its cessation.

The carbohydrates, when either partially, or specially when wholly converted, form easily assimilated articles of diet, and give rise to no inconvenience, unless when, like any other food, they are taken in excess. They are quickly absorbed, and thus form a most valuable addition to our fat-producing or energy-saving foods.

It is by attending to such points as I have drawn attention to in managing the dietary of infants and invalids, along with an improved hygiene, that we may in the future with confidence expect a greatly diminished rate in infantile mortality, and a much improved condition in the general health amongst the new members of our population.

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