MILK.

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GRACE ALLINGHAM.

OUTLINE.

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MILK.

The use of milk is general and not limited to any class or locality; it is regarded as a necessity by almost every family and because of this, we cannot glean too much information regarding it. This is doubly important when we think of the failure of Americans to appreciate the food value of milk and its products. Although this is one of the greatest dairy countries in the world, it does not lead in the per capita consumption of dairy products. In some of the older European countries two or three times as much milk and cheese is consumed per capita as in the United States. However, the average consumption of milk is high in many parts of this country, and, assisted by improved methods of production and transportation, it seems to be increasing.

Milk contains all the ingredients needed for nourishment; that is, it furnishes the materials which build up the body and keep it in repair, and also those which supply it with fuel to keep it warm. and to furnish the energy needed to do its work. It is not a perfect food, but it is a complete food; that is, it contains all the food elements but not in the proportion needed. However, it is the most nearly perfect food, and is one of the best types of what may be termed a well-balanced food. It is not only the best, but one of the cheapest of human foods, especially as a source of proteid. But its use as a food is not fully appreciated. It should be regarded as a regular article of diet, as bread, meat and vegetables, remembering, of course, that the diet of the adult must not contain so large a percentage as that of a child. The fact that nature has provided milk as the sole article in the diet of a child for a cer-

tain period of its life only augments the importance of its place in the general diet.

Milk is a whitish opaque liquid. To the ordinary observer it appears to be a perfect solution, and is commonly regarded as such, but when placed under the microscope it is seen to consist of a clear transparent fluid containing many minute globules of various sizes. These are held in suspension in the liquid in the form of an emulsion; the fluid part, called the milk serum, consists of water and all the other constituents of milk except the fat, and these other constituents, although solids when separated and dry, are practically all dissolved in the water, or, as is said, in solution. The globules are little bodies of pure fat scattered through the serum and not dissolved; they are semi-solid, and the mixture they form with the serum is called an emulsion.

The milk most universally used is that of the cow, although goats' milk is used to quite an extent in the mountains of Switzerland and in other European countries. For some eastern tribes it is a staple variety of milk. It is not used in the United States except by very poor foreigners.

Both asses' and mares' milk are used in the Steppes of Russia and in Siberia for the manufacture of koumiss.

Since the infant obtains its milk from its mother, it is interesting to compare it with the milk of the various animals. The mother's milk differs from cow's milk chiefly in that the percentage of proteids is low, and that of sugar, high.

The milk secreted for the first few days after birth of the young in both humans, and other animals, is called colostrum. It

differs quite considerably from the milk secreted later. The human colostrum is yellower and more alkaline than the fully formed milk. It also contains more solids, and coagulates on heating. It contains no caseinogen. It has a laxative effect which is necessary for the first food of the new born animal.

Schaffer gives the composition of human colostrum twenty-four hours after delivery as follows: water, 84.38; solids, 15.62; salts, .51.

The colostrum of cow's milk is not used until after the ninth milking after delivery; it has a high specific gravity and its fat has a higher melting point than that of normal milk. Its proteid ø coagulates upon heating.

There are various causes for the variation in the composition of normal milk. The proportion of the constituents depends largely upon the kind of cows. As a rule, similarly bred cows, under like conditions, give about the same quality of milk at corresponding times during the period of lactation, although sometimes the composition of milk from cows of the same breed may vary as much as that from cows of different breeds. The feed given a cow has a much greater influence upon the quantity of milk produced than upon its quality.

Excepting meats, there is probably no one article of food which is liable to so wide a variation in its percentage composition as the milk which the average milkman supplies. It is then difficult to state with accuracy the composition of milk. But Schaffer has given an average composition which is accepted as satisfactory:

Water, 8.28 Solids, 17.72

Caseinogen,	3.57
Albumin,	.75
Fat	6.47
Lactose	4.34
Salts	.63

Lactic acid, less than one-half per cent

In other words, one hundred pounds of good milk contain about eighty-four pounds water, six pounds fat, four pounds of milk sugar, four pounds of caseinogen and albumin, and six pounds salts.

The fat varies in quantity more than any other part of the milk, running as low as two parts in one hundred, and as high as seven. Some consider that the presence of citric acid in milk is not from the food, but produced in the mammary gland. It occurs as citrate of lime.

The chief carbohydrate compound which occurs in milk is lactose, or milk sugar. It is less soluble than the other sugars and has only a faint sweet taste. Its reducing power is inter-mediate between that of dextrose and maltose. Lactose is very resistent to the inverting ferment of yeast and so undergoes the alcoholic fermentation very slowly. Of all the sugars, it is most readily affected by the Bacillus Acidi lactici. It is found in varying quantities in the milk of all animals with one exception. In the Egyptian buffalo it is replaced by another sugar.

Although lactose is not fermented by yeast, other shizomycetes cause alcoholic fermentation in it, as is shown in the manufacture of koumiss and kephir.

The fat of milk, or butter fat, consists of several different fats. The chief of these are the same fats that make up the bulk of fat meat (tallow, lard, etc.) as well as many vegetable fats.

These are called stearin, palmitin, and olein. Besides these three fats there are others in smaller amounts, but of considerable importance, since it is to them that the flavor and aroma of the butter is due. The amount of fat in the milk varies in the different animals, according to the climate in which they live. Those living in the far north require more fat in the diet, and the milk is richer in fat; while those in more temperate regions require less fat in the diet, and the milk contains a smaller percentage.

The principal nitrogenous compound of milk is caseinogen. In chemical composition the caseinogen differs from the other protein compounds of milk in that it contains both phosphorus and sulphur. Besides the caseinogen there is a certain amount of albumin present, called lact-albumin, or albumin of milk. This is somewhat similar to the albumin which occurs in blood and in white of egg. The quantity of albumin is very much smaller than that of the casein, being on the average about one-seventh of the total protein. There are other nitrogenous substances occurring in milk, but in insignificant quantities. The total protein of milk should not vary in and great degree. Its average is about twenty-five per cent of the total solids.

The salts of cows' milk are K_2O, CaO, P_2O_5, Na_2O, MgO, Cl

$Ca(C_6H_5O_7)_2 \cdot 4H_2O$ (calcium citrate)

There are also small quantities of oxygen and nitrogen and carbonic anhydride.

Schaffer gives the following table showing the composition of milk from the different animals:

Animal	H O	Caseinogen and Albumin	Fat	Lactose	Salts
Dog	75.4	9.91	9.57	3.19	.73
Cat	81.6	9.08	3.33	4.91	.58
Goat	86.91	3.69	4.09	4.45	.86
Sheep	83.5	5.74	6.14	3.96	.66
Mare	90.06	1.89	1.09	6.65	.31
Ass	90.	2.1	1.03	6.3	.3
Pig	82.37	6.09	6.4	4.04	1.06
Mule	89.3	2.6	1.9	6.03	.53
Hippopotamus	90.	3.7	4.5	1.	.1
Camel	86.3	3.07	2.9	5.8	.6
Elephant	67.85	3.09	1.95	8.84	.65
Dolphin	48.67		43.76		.46
Buffalo	82.20	4.13	7.95	4.75	.97
Rabbit	69.50	15.54	10.4	1.95	2.56

As to the nutritive and dietetic value of milk, enough cannot be said. For children it is almost indispensable, and in certain diseases, an exclusive milk diet is prescribed.

Thompson gives the following diseases and conditions in which an exclusive milk diet is desirable:

1. In infancy for the first year and some times for the first eighteen months.
2. All acute diseases of young children.
3. Typhoid Fever.
4. Acute Brights' Disease, and sometimes in chronic nephritis.
5. Chronic gastric catarrh.
8. Neurasthenia.

For a man in health a pure milk diet is "slow starvation." If kept too long upon it, he develops a condition akin to scurvy. Combined with bread or cereals it makes a complete dietary, but excessively bulky. But in certain diseased conditions milk furnishes all the nutriment necessary for a time.

The patient for whom the milk is prescribed may dislike it;

the taste must be altered; this may be done by the use of extract of coffee, weak tea, caramel, ginger, chocolate, cocoa, salt, pepper, meat extracts, malt extracts; or it may be served in the form of junket, custards, gruels, etc.

If the patient is unable to digest fat in any form, skim milk must be used. Boiling the milk increases its digestibility for some individuals, but in general decreases digestibility and alters the flavor undesirably. Dilution with water causes it to form in smaller curds in the stomach and thus digest more readily.

Digestion may also be increased by dilution with alkaline or aerated water, barley water, by the addition of alkalies, acids, and other substances.

In certain cases some method of predigestion needs to be employed. Peptonized and pancreatonized milk are used, as well as koumiss, kephir, matzoon, etc.

There is a great variety of pepsin, peptonizing powders, etc., offered on the market for predigesting milk, or to complete a portion of the digestive process outside the body.

In general, milk ranks as a very digestible food, but when we come to speak more definitely, we meet some difficulties.

The protein of milk, especially when it is used with other food materials, is quite readily and completely digested. When milk is mixed with other foods, it does not, of course, form such large curds in the stomach when acted upon by the rennin, the mixture forming a mechanical separation; this renders it more digestible. The protein of vegetable foods is much less completely digested. In general, it may be assumed that about five per cent of the

fat of milk will usually escape digestion; if the diet contains a good deal of fat, more of the fat may escape digestion. It is thought that the sugar of milk is as completely digested as cane sugar. So we see that milk ranks among the most digestible of the animal foods in respect to all its ingredients.

The chief proteid occurring in milk is caseinogen. It is this which is acted upon by rennin of the gastric juice and converted into casein. When milk is allowed to stand at an ordinary temperature exposed to the air, the chief change it undergoes is the lactic acid fermentation. The acid formed precipitates a part of the caseinogen, but this is a different thing from the conversion of caseinogen into casein. It acts most readily at a temperature of 40°C. Owing to this coagulation, milk becomes a solid food soon after it enters the stomach. In coagulating, the curds entangle the fat globules, but they are soon dissolved by the pepsin and converted into peptones.

The experiences of different persons with cooked and uncooked milk are quite varied. The more common experience seems to indicate that cooking or heating the milk makes the proteids somewhat more difficult for most persons to digest, but there are exceptions to this rule. For instance, there are persons who cannot take fresh milk with comfort, but with whom boiled milk agrees very well. The usual period for the digestion of milk in the stomach by gastric juice, is about three hours.

The salts and H O of the milk and possibly to some extent, the sugar, are absorbed in great part from the wall of the stomach. When not absorbed by the stomach, they pass into the intestines

and are taken up by the villi. The pancreatic juice saponifies the fat, which is then absorbed by the lacteals of the villi.

Cream, butter and cheese are used almost as extensively as milk, and are such important products that they deserve consideration here. When it is desired to raise cream the milk should be put in a cold place, where it will not be disturbed, as soon as possible after it is received. It will aid the cream in rising if the temperature of the milk is raised to about 100°F and then lowered by placing the dish in cold water. This cannot be done unless the milk is in good condition, as the high temperature may cause it to sour before it can cool sufficiently to prevent souring. Cream gradually becomes thicker the longer it is kept. It ought to be kept as near the freezing point as possible; it should be placed directly on the ice, or, better yet, be entirely surrounded by ice.

When the globules of fat rise in the milk, they entangle among them a considerable amount of milk which is removed with the fat as cream. Cream, then, is the butter fat of the milk, with some protein and carbohydrates due to the milk it contains, and contains on the average about four and one-half times the amount of fat contained in an equal volume of milk. The fuel value of a pint of cream is about 1,425 calories, or about the same as one and one-eight pounds bread, or one and one-half dozen bananas, or four and one-half pounds potatoes. Four quarts of whole milk would not furnish quite as much energy (1300 calories), but would increase the protein over six times. It is thus seen that cream is valuable chiefly for its heat giving properties, and that the skim milk con-

tains the valuable protein.

The essentials for making good butter are good milk, clean utensils, a place where the cream can be kept and ripened at the proper temperature, plenty of cold water, or an ice supply, and good judgment in churning and working. The good quality of the butter, of course, depends upon the proper ripening of the cream. As it is everywhere recognized today, the ripening of cream is simply a matter of bacterial growth, and whether the cream is ripened in a proper, or an improper manner, depends upon the number and kinds of bacteria that chance to be in it at the beginning of the ripening.

Among the number of kinds of bacteria found in the cream there are a few species whose growth in the cream produces there a pleasant, desirable aroma and flavor. Pure cultures have been prepared in laboratories, of the bacteria that sour and give the desired flavor and aroma to cream, and these cultures have been used in practical experiments. The milk being first sterilized to kill all "wild" bacteria, the desired culture is then sown. These are used somewhat widely at the present time in European countries, having started in laboratories in Denmark and Germany. Some desirable species are now put up in such form that they can be readily distributed to the creameries of the country. Their use is rapidly growing, and in the opinion of some of our best butter makers, it will not be long until it will become almost universal.

When it is considered that a pint of cream retails at from twelve to twenty-five cents, and a pound of butter from eighteen to thirty-six cents, and that the latter is worth two and one-half times the former as a source of energy, it will be seen that butter

is a more economical form of food than the cream.

If bacteria are desirable allies of the butter maker, they are absolute necessities to the cheese manufacturer.

The cheese consists of the protein part of the milk, and this is precipitated by the use of rennet. This is prepared from one of the stomachs of the calf, and when added to the milk, causes the same changes which occur when milk enters the human stomach and is acted upon by the enzyme rennin. Cheese consists essentially of the protein and fat of the milk. In its manufacture, the first step is the precipitation of the casein. This is accomplished in one of two ways: rennet, which is prepared from one of the stomachs of the calf, is added. This is the usual way. Sometimes the milk is allowed to sour, or an acid, as vinegar, is added, to accomplish the same thing. If the latter method is used, very little fat is carried down with the casein. The next process is squeezing the whey from the curd. If much pressure is used, the cheese is termed "hard;" if less pressure is used, it is termed "soft." Soft cheese does not keep well and should be used soon after making. Hard cheese is more easily digested than soft cheese. The next step after pressing out the whey, is the ripening, due, again, to the action of certain bacteria. The cheese is allowed to stand for a period, until thisprocess is accomplished.

Cheese is a very concentrated form of protein food and is difficult of digestion; the fat forms a waterproof coating, thus preventing the access of the digestive juices to the casein. The casein is more easily reached, of course, when the cheese is well chewed, or grated. It is a good plan to dissolve it and mix with

other forms of food. Casein forms soluble compounds with alkalies; bicarbonate of potash is often added to cheese for this purpose, thus removing the only objection to cheese as a food. If cheese is properly digested in the stomach, there is no further difficulty, as it is absorbed from the intestines as easily and completely as meat.

The composition of cream cheese, which may be obtained at twenty cents a pound, is 34.2% water, 25.9 protein, 33.7 fat. This shows how great its economical value is, and how important as a food, if an alkali is used, to make it more digestible.

The by-products of milk, buttermilk and skim milk, are certainly of great importance in the food problem, especially of the poorer classes. When the cream is removed, we have remaining "skim milk." Even after average milk is skimmed it contains nearly 10% of nutritive ingredients. The amount of fat varies greatly with the method of creaming. A pound of skim milk contains a little more protein than the same weight of whole milk and about one-half the fuel value. The value of skim milk as food is not generally appreciated. Of course if taken by itself, one has to drink a large quantity to get the needed nourishment, and it does not usually satisfy the sense of hunger. But when taken with bread or used in cooking, it forms a very nutritious addition to the food.

A pound of round steak at a cost of twelve and one-half cents contains about .18 pound protein and has fuel value of 870 calories. Two and one-half quarts skim milk, costing two cents per quart, will furnish about the same. Two quarts of skim milk has a greater nutritive value than a quart of oysters which cost fifty cents.

Atwater made a computation in which he found that a meal con-

sisting of ten ounces of bread and one pint skim milk furnished .09 pounds protein and 925 calories at a cost of four cents, while a restaurant lunch consisting of soup, beef, potatoes, turnips, bread, butter, and coffee with milk and sugar, furnished practically the same (.05 pound protein and 940 calories) at a cost of from fifteen to twenty cents. When these facts are fully understood, skim milk will doubtless be more wisely utilized.

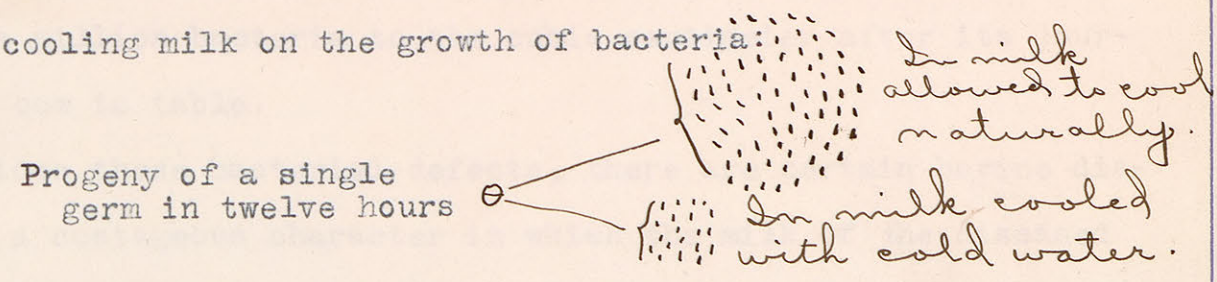
Besides skim milk there is another important by-product resulting from the manufacture of butter - buttermilk. The average composition of buttermilk is quite simialr to that of skim milk, though it contains slightly less protein and sugar and a little more fat. The fuel value is about the same. An ordinary glass of buttermilk contains as much nourishment as one-half pint oysters, or two ounces bread, or a good sized potato. Buttermilk is very easily digested owing to the absence of fat, and to the fact that its casein is present in a finely flocculent form.

Both heat and cold have their effects upon milk? It is well known to all who have endeavored to keep milk sweet for any length of time that the cooler they keep it, the longer it remains sweet. A temperature lower than 32° is injurious to milk, and higher than 75°. The heating and cooling of milk bear a very close relation to the bacterial action. The temperature of milk as it is drawn, is very favorabe to the growth of various organizations, and the temperature, with the milk, form one of the best mediums for the growth of a number of different bacteria.

Milk, if left to itself invariably undergoes a fermentation change, generally known as souring. The acidity gradually increases until finally the amount of acid developed causes a coagulation or

precipitation of the caseinogen, and milk is said to curdle. This change is brought about mainly by a fermentation of the milk sugar, lactic acid being the chief product formed. The primary cause of this change is not to be found in any atmospheric condition, such as damp or hot weather, or sudden changes in temperature, but is dependent on the growth of certain species of bacteria that get into the milk. Notwithstanding the popular notion, thunder storms in themselves do not sour milk. If milk is free from living organisms, electrical discharges are unable to affect its acidity. It is the conditions that usually accompany the thunder storm, such as damp, heavy weather - conditions that favor rapid bacterial growth - that are the real cause of the more rapid changes. The lactic acid bacteria are so widely distributed that their presence in milk is always assured, and the fermentative change that they cause may be considered as normal. After the lactic acid fermentation there comes a putrefactive fermentation.

H. L. Russell, of the Agricultural Experiment Station of the University of Wisconsin, gives the following figure to show the effect of cooling milk on the growth of bacteria:



The appearance of "gassy" milk is due entirely to the presence of gas-producing bacteria. Quite often it is found that milk curdles quickly without the production of much acid. This premature curdling is due to an abnormal fermentation, produced by a large variety of bacteria, which are, as a rule, spore bearing organisms,

and therefore possess high powers of resistance. It is for this reason that boiled or heated milks almost always undergo this type of fermentation. The organisms producing these quick curdling fermentations are, as a rule, bacteria that are associated with fecal matter which finds its way into the milk in a variety of ways.

Milk often undergoes a change in its consistency, becoming slightly thickened or sticky, then in a more advanced stage, slimy or slippery, until it reaches a condition where it can be pulled out into long strings. When it is in the condition where it adheres to anything it touches, the terms, ropy, stringy or thready milk, are applied. The causes of these abnormal fermentations are due to the presence of certain species of bacteria that for the time being gain the ascendency over the normal milk bacteria. The bitter condition in which we some times find milk is also due to bacterial action. Other fermentations, the result of bacterial action, are the formation of alcohol, due mainly to yeasts, pigment fermentations such as blue, red or bloody, yellow and green milks; but these do not occur frequently. According to Sedgwick, milk may contain a million bacteria to the cubic centimeter after its journey from cow to table.

Besides these bacterial defects, there are certain bovine diseases of a contageous character in which the milk of the diseased animal may be infected with bacteria dangerous to health. In some instances the milk is changed in appearance by the disease, while in others it is not. Anthrax fever and tuberculosis and diptheria are disseminated in this way. The majority of bacteria that are capable of causing contageous diseases gain access to milk after it is drawn. Persons convalescing from fevers may infect the milk.

Typhoid fever is often disseminated in this way. The greatest danger that arises from a diseased milk supply comes from the poison forming bacteria that get into it through improper handling.

The most common frauds practised with milk are the removal of a part of the cream and the addition of water. Color is sometimes added, but the many other substances which the milkman is often accused of using, are really quite rarely used. Adulterated milk is unsafe, as it contains less food value than it should have, and the consumer is deprived of nourishment which is supposed to be given. But this is not the worst about milk that has been adulterated by water. If a dairy may is dishonest enough to water his milk he will probably not be careful about the purity of the water added. Impure water contains many bacteria. Most of them are perfectly harmless, but in such an immense number there are likely to be disease germs. Epidemics of contagious diseases have been traced directly to contaminated water added to milk for the purpose of adulteration.

Various chemicals are some times added to the milk to prevent its souring. A few advocate their use, but the weight of opinion is against them. The most common substances contain salicylic acid, boric acid, borax or formaldehyde. These are not poisons, but when taken regularly in small doses in milk they may have an injurious effect on the system. It is easily seen that if preservatives prevent the natural changes of milk they may prevent its digestion in the stomach, the process of digestion being similar in some respects to the fermentations. Another objection to chemical preservatives is that one may become accustomed to taking less care of

preserved milk, than if it were not preserved, thus making it still more liable to contamination.

Condensed milk is simply cow's milk from which a large proportion of the water has been removed. This is accomplished by evaporation under pressure. It is usually reduced to one-third its original volume, so that in using it, just twice its quantity of water is added. Condensed milk is more easily digested than fresh cow's milk. In the process of condensation, the caseinogen undergoes some chemical change which renders it unfitted for forming dense or large clots.

There is one defect regarding its nutritive value. For some reason, when the milk is being condensed, a comparatively large amount of cane sugar is added. This makes it so sweet that when the proper amount of water is added, it is still too sweet, and more must be added. This, of course, reduces its fat content, and this is a serious defect. In cities near condensing factories the unsweetened condensed milk is sold in bulk and this proves very satisfactory.

Koumiss is prepared from mare's milk, in some of the eastern countries, but in the United States it is made from cow's milk, by adding an artificial ferment. One authority gives the following recipe for home made koumiss:

2 teaspoons wheat flour dough
2 tablespoons millet flour
1 tablespoon honey
1 tablespoon beer yeast

Mix into a thin paste with milk and put in a warm place. When fermented, put in a linen bag and hang in a covered jar with sixteen pounds fresh milk for twenty-four hours. Skim, stir for an

hour, bottle and cork tightly and keep in a cool place.

Alcohol is developed during fermentation, from the lactose. Of course, if mare's milk is used, the per cent of alcohol is greater. In the east, it is used as an alcoholic drink. Here it is found to be of great service, when the digestive power is weakened, and in certain diseases.

Kephir is another form of fermented milk which resembles koumiss, and differs in that it contains three varieties of ferment. Matzoon is a form of milk in which fermentation is produced by a peculiar ferment much used in Syria and possesses the same general properties that koumiss has.

Returning to the subject of milk in its natural form, there is no question in regard to it, more important than its care. A great deal depends upon the care it receives. Of course the utmost cleanliness must be observed by the milkers and those having subsequent charge of it. The importance of cooling it as quickly as possible has been mentioned before. After cooling it, it may be bottled, and in this way kept for some time.

The aeration of milk is used quite often to aid in climating the animal odors that are sometimes obnoxious. Aeration as ordinarily practised has a double effect. Besides airing the milk, it usually lowers the temperature, and the cooling is thus partially accomplished at the same time.

Drawing off the odors by heating the milk is also highly recommended. Pasteurization of milk is now being extensively practised and it is found to be an especially good means of preservation, if it is impossible to cool it sufficiently. A large propor-

tion of the germs are killed by the heat. When sufficient heat is used to kill all the germs the product is called sterilized milk, and may be kept in good condition indefinitely.