

The Action of Bacteria on Foods.

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The subject of Bacteriology is one which has but recently been brought before the public. The discoveries which have been made along this line in the last fifty years have been marvelous, and there is no doubt but what the work is just fairly begun. There is a wide field open for investigation by scientists. The necessity of this investigation is obvious enough when we consider the close relation which bacteria bear to human life or indeed to any kind of life, either animal or vegetable. A knowledge of bacteria is necessary to every individual, for we meet them every where in life; they are omnipresent. The earth, the water and the air about us are supplied with them. They are very social and dwell with us in our houses, sit with us at our tables, cling to our clothing, and take up their abode in our food and drink. They are our greatest friends as without them it would be impossible to live. They are also our greatest enemies, for they are the initiative of the greater part of all the disease and death in the world.

We will now turn to an investigation

of the microorganisms. For a considerable time after they were discovered they were thought to be members of the animal kingdom. As late as 1835 they were placed among the Infusorians. This was partly due to the power of motion which had been detected in bacteria. But of course it is now recognized that plants as well as animals have motion. The chief differences between animals and vegetables low down in the scale of life are two, namely, difference in structure and development, and difference in their food. Investigations prove that bacteria possess motion, are free from chlorophyll, and feed sometimes upon products of decomposition, these characters would place them in the animal kingdom. Yet by their structure and capsule of cellulose and by their life history and mode of growth they should be placed in the vegetable kingdom. In 1853 Cohn classified them as belonging to the vegetable kingdom, and since that time they have been more limited in classification; yet, we have today no scientific classification for bacteria, as there are such a variety, and moreover, different physical conditions produce a change in the individual character of the

same specie. Among the six or seven hundred species of microbes, present knowledge is not sufficient to give any more than a general classification. We know that bacteria are closely related to the molds and yeasts. We know also that they are fungi, for they contain no chlorophyll, and that there is no sexual reproduction as their mode of multiplication is by division, we may therefore say that bacteria are single-celled microscopic plants, usually destitute of chlorophyll and reproducing by fission. Bacteria are classified according to form also according to biological characters.

The bacteria which are the special enemies of mankind are the pathogenic, while those which are perhaps the most useful are the saprophytic; yet, in many instances they are the cause of food-poisoning which induces many diseases; and recent investigations have traced many fatal cases to the action of saprophytic bacteria. Injurious microorganisms in foods are, very fortunately, usually killed by the cooking; then, again, large numbers of bacteria are of no harm whatever. This lessens the dan-

ger, which at first seems appalling, when we remember the large numbers which we encounter on every hand. But it is well to know the bacterial flora, both good and bad of foods, that we may be able to avoid food-poisoning and infection by pathogenic germs. In the study of bacteria in foods there is hopes of some knowledge being obtained of the habits and effects of microbes.

It is only during the last few years that physicians have learned to recognize food infection as a frequent cause of illness; this fact has been carefully studied, and many cases have been traced to the exact cause. It can now be shown that Cholera infantum is a result of infected or poisonous food. It is known that many cases formerly thought to be caused by accidental poisoning by metallic substances are also due to infected food and that the same agency may induce diseases simulating typhoid fever and pneumonia. Usually the infection of the food is the essential thing. In many cases the nature of the chemie bodies which cause the symptoms of disease is en-

tirely unknown, also the nature of the bacteria which produce these poisons is obscure. In some cases the active chemical agent is formed in the food before it is taken into the body; in others it originates from the continued activity of the bacteria after introduction into the body. Some cases are those of intoxication while others are more truly infection. But in all cases infection of the food occurs either before or after its introduction into the body.

The following are some of the sources of dangerous infection.

(1) Persons have been infected by eating the flesh or using the milk of a diseased animal. This has repeatedly been shown to be true. One case studied by Gartner of Jena was as follows:

A cow suffering with disease was killed and several persons partook of the flesh, some eating it raw, others eating it partly cooked and still others eating it entirely cooked. In the first case the fatality of the disease was in proportion to the amount of the flesh taken. One young man taking eight hundred grams died in thirty-six hours.

all partaking of the meat raw were seriously affected, while the cooked meat had a less serious effect. Tuberculosis (?), anthrax, glanders, and pleuro-pneumonia are diseases which may be transmitted in this way.

(2) Another source of dangerous infection is inoculation with specific microorganisms outside the body of the animal. Illustrations of this are very common in the spreading of typhoid fever, Cholera, and diphtheria by infected meat and milk.

(3) Perhaps in the majority of cases harmful infection is due to the presence of saprophytic and toxicogenic bacteria. Food derived from healthy animals and kept free from infection by pathogenic bacteria often develop most poisonous properties. Many of the bacteria with which meat and milk become infected belong to the saprophytic organisms. An illustration of this is found where frozen custards of two different flavors were served at an entertainment. Those who partook of the lemon flavored custard suffered no ill effects, while all who partook

of the vanilla custard became seriously ill. The illness was finally traced to its true source. It was found upon investigation that the vanilla cream had stood for two hours on a hot day in a close room where the air was foul from decomposition products. This was sufficient opportunity for it to become infected with saprophytic bacteria, while the lemon custard had not been exposed to such conditions. In another case where chicken salad was served fresh no ill effects came from it, but a part of the same salad was kept for three days in a close place where the air was foul, then served, and every one who partook of it became suddenly ill. Many cases of poisoning of this nature have been traced out and carefully studied.

It seems very strange to us that a truly saprophytic germ could induce disease and death to such a marvelous degree. There are two ways in which this result may be brought about. First the poison formed in the food before it is taken into the body

or the formation of the poison may continue in the body. In the first place the germ is one that can not continue to live after its introduction into the body. An instance showing this to be a fact is given in the case of a family that partook of a warmed-over veal pie and all were taken violently ill. The pie contained bacillus cultures which had a delicate aromatic odor and when fed to mice killed them in a short time, while inoculation with the bacillus was without effect. The bacillus did not grow at 36°C , but when grown at lower temperatures produced a chem-ic poison which caused the dangerous effect upon the system. The "ptomaines" that are formed in foods as a result of the activity of the saprophytic bacteria may properly be called putrefactive alkaloids; while the poisonous bacterial proteids are called toxalbumens. It is thought that the poisonous proteids are more frequently present in infected foods than the "ptomaines". Doubtless some of the toxalbumens are absorbed by the alimentary canal; if they were not fatal

Cases of food-poisoning would be more common than they are.

Large numbers of cases are on record where persons have been poisoned by infected meats, especially sausage; the infection was here traced to the method of preparation. The flesh was allowed to stand for three or four days in blood at a high temperature; this gave ample opportunity for the development of the ptomaines or toalbumens. Another method of preparation was to hang the sausage in the chimney and allow it to cure; by this method putrefaction would probably occur.

Cheese-poisoning is probably due to tyrotoxin which is produced by a bacteria in the cheese.

Ice-cream poisoning is due to the products of putrefaction formed in the milk due of course to the existence of bacteria there. They may be formed before the ice-cream is made, but are more frequently formed when it has been allowed to melt. Custards, creams, salads and almost any meat or milk preparation if exposed to proper conditions may produce illness by food-poisoning.

Meat and milk seem to be the principle foods which are infected. This is due to the fact that they are a more favorable medium for the growth of bacteria than any other foods.

Besides the deleterious and dangerous effects of saprogenic bacteria upon foods, we have the infection by pathogenic bacteria. It appears from investigation that the organisms of suppuration are the most common, but we have typhoid fever, diphtheria, Cholera, scarlet fever, tuberculosis and other diseases transmitted thru foods.

The general use of milk and its products as an article of diet makes it the most important food to be considered in this connection, also, since it affords an ideal medium for the growth of bacteria, its adaptability for conveying disease is much greater than that of any other food. Its sources of pollution are so many that it is very difficult to secure perfectly sterile milk. At the time of milking there is much danger of infection unless the greatest care possible is exercised. There is contamination from the animal, when its

coat is unclean, particles of dirt containing bacteria drop into the milk, which being warm will cause them to multiply very rapidly. The influence of foul air in the place of milking is very obvious. Bacteria settle to the ground and during the period of milking there is ample opportunity for contamination from the air. Again, the milker is a source of risk. His hands and clothes may both readily convey harmless and pathogenic germs to the milk. Several cases are on record where it appears that milkers have conveyed germs of infectious diseases from their homes to the milk. In this way the disease would be scattered over a large territory if the milk and its products were sold to many people. Another source of infection is the risk in transit. Unclean utensils may be used, the milk may be diluted with impure water or there may be delay in conveyance which gives increased opportunity for infection; all of these things contribute to the bacterial flora of the milk. We may mention the fact here, that the first milk which flows in the process of milking is rich in

bacterial life, for bacteria from the outer surface of the animal enter the milk ducts and pollute the milk which has remained in the ducts since the last milking. However, most of these belong to the lactic-acid fermentation group and very rarely contain any pathogenic germs. Yet sometimes the tubercle bacilli is found in the milk when it is first drawn, where cows have tuberculosis of the udder.

With these many sources of contamination, milk and its products - Cream, butter, and cheese - are very apt to be teeming with bacteria by the time they reach the consumer, unless precautions are taken on every hand to keep everything spotlessly clean. Perhaps tuberculosis is more apt to be conveyed through milk than almost any other disease because of the fact that it is quite common among cattle and ^{may} be transmitted through the milk to human beings especially those predisposed to the disease. Bacteriologists differ concerning this fact however, and some declare that bovine tuberculosis will not infect man. If this can be positively proven to be the case, then the danger of this disease from milk is no greater than ty-

phoid fever or some of the other infectious diseases.

The only thing which can be recommended as a remedy for the infection of food with pathogenic germs is the strict observance of sanitary laws, perfect cleanliness, and a greater knowledge of the nature of bacteria and their activity.

We have already mentioned facts enough to show that the deleterious and dangerous effects of bacteria are enormous in relation to food alone. Nothing has been said concerning their attack upon foods which cause decay and putrefaction. This is a very important subject, since it becomes necessary to provide some means to check their activity or prevent their entrance into foods if we would keep them for any length of time. This subject is treated under the head of preservation of foods, but we will not enter into it here.

We will now discuss the beneficial effects of bacteria. We have already seen that they are one of the greatest enemies of man; but further investigation shows that we depend entirely upon bacteria for the manufacture of some of our food products and the development of the flavors of many others.

By acetic acid fermentation we are able to produce vinegar, which is an important product. By its use we are enabled to preserve large quantities of vegetables which would otherwise go to waste. But besides this, acetic acid fermentation is at work upon nearly every farm. The farmer extracts the juice from the apple and grape, places it in the cellar, and bacteria do the rest. Cider and wine is the result. Alcohol, beer, whiskey, and all the various liquors are the result of bacterial action. The formation of acetic acid is essentially an oxidizing process. The acid may be produced from various organic compounds but in practice ordinary alcohol ($C_2H_5(OH)$) always serves as its basis. The reaction occurs in two stages as follows; (1) $C_2H_5O + O = C_2H_4O + H_2O$; (2) $C_2H_4O + O = C_2H_4O_2$. It has always been known that the mother of vinegar is necessary in acetic fermentation, but just what its action is was unknown until later years. Persoon who studied it in 1822 named it mycoderma. Pasteur called it mycoderma aceti but did not regard it as a bacterium. Hansen found that it was not a single organism but that it belonged to the general group of bacteria.

Inycodeerma was changed to *bacterium* and *aceti* and *pasteurianum* were added as the names of the two distinct species isolated by Hansen; but others have been discovered and today we have a long list belonging to the acetic bacteria.

There are quite a number of fermentations significant in the handling of food products, upon the farm or elsewhere, not connected with acetic fermentation. The object is to preserve the foods from putrefaction, and at the same time impregnate them with pleasant flavors, by causing them to undergo a fermentation of which the production of lactic acid is a prominent feature. Lactic bacteria prevents the growth of other bacteria and delays or prevents putrefaction.

One of these foods which is very common is sour kraut. It is made from a mass of cabbage leaves mixed with salt and allowed to ferment. There is sugar in the cabbage leaves which serves as food for the bacteria. Lactic acid is produced. One species of bacteria and two of yeast have been found in the fermenting sour kraut and are believed to produce the flavor upon which the value of the sour

krout depends.

Vanilla extract which is derived from the vanilla bean is secured by means of a fermentation process. When the bean is first taken from the plant it possesses no flavor whatever. The beans are collected and put through a process of sweating; this treatment starts fermentation which produces the characteristic flavor.

Cocoa and Chocolate so widely used though out our country are very valuable as ~~a~~ nourishing foods as well as for their flavor. We must depend entirely upon bacteria for the production of the delicious flavor of our Chocolate and cocoa. It is obtained in much the same manner, as is the flavor of the vanilla extract, (by putting the cocoa bean through a process of sweating which starts fermentation.)

In some countries a form of sour food is made from beans which are allowed to undergo acid fermentation in much the same way as sour krout.

There are various milk preparations which are made by the action of bacteria, some of which are very valuable in the treatment of certain diseases. Kourmisse is a very valuable fermented milk, also Kefir and Matzoon.

Yeasts produce the alcohol of these preparations and bacteria produce the flavor.

Perhaps in no one industry is bacteria of more importance than in that of dairying. The dairymen must guard against unfavorable bacteria and secure the development of those which produce the best flavors. Upon the kind of bacteria developed depends the flavor of butter and cheese and upon these flavors depends the value of the products. Hence, the control of bacteria becomes a very great problem to the dairymen.

In buttermaking the ripening of the cream is the all important step in producing the flavor of the butter. Today no one questions the fact that the flavor produced by the ripening of cream comes from bacterial action, although enzymes may be present.

The purposes in ripening cream are as follows:

1. The most important purpose is the production of a desirable flavor and aroma. Butter made from unripened cream lacks the peculiar flavor and aroma which is characteristic of high-grade butter.
2. Butter has much better keeping qualities when properly ripened.

3. The yield of butter is increased by cream-ripening.

The cause of cream-ripening is the enormous growth of bacteria, which occurs in a comparatively short time when kept at a proper temperature. In normally ripened cream there is usually from three hundred million to six hundred million bacteria per cubic centimeter. The cream thickens, sours, acquires a characteristic odor, all of which are due to the products of bacterial growth. The bacteria also softens the fibrin which surrounds the globules of fat so that in churning they adhere readily. Lactic acid is produced and it is thought that this is where the flavors and odors are formed. However, practically nothing is known of the nature of these flavoring products. We do not know whether they are the by-products of the chemical decomposition, or whether they are excretions from the bacteria. They are not present in large quantities, though, they are strong enough to give the butter the characteristic butter flavor.

Since different species of bacteria develop different flavors the question with butter-makers is to control or check unfavorable species and introduce those which give the desired

flavor.

About ten years ago the idea of controlling cream ripening was first conceived and put into practice in Denmark. The method was to kill all unfavorable germs by pasteurization; that is, heating the milk to 165°F., then producing the desired flavor by the introduction of pure cultures. Pure cultures are now manufactured and sold to butter makers for flavoring their butter. This process was not used very extensively in our country, but a "starter" composed of two or three species of lactic bacteria, which is introduced into the cream, without pasteurization, is quite commonly used here.

The effect of bacteria in the manufacture of cheese is even more important than it is in butter-making, for cheese is absolutely of no account if not properly ripened. This ripening process takes place in the curd after it is molded into shape. The flavors vary greatly from the slight flavor of American cheese to the characteristic flavor of Limburger cheese. These flavors are produced by microorganisms.

Little do we think as we relish our bread, butter, and cheese or sip our chocolate

that such an invisible, seemingly insignificant organism as a bacterium was instrumental in producing such delightful flavors. We find we owe much of our pleasure and a very great deal of our profit to these microorganisms. While they are our enemies they are also our greatest friends. We should strive to learn more about them that we may control them in their deleterious and dangerous effects, and nurture them in their beneficial effects.