

It grows slightly along the stick. It does not grow at a temperature of 102° F. On Agar Plate it forms small pearly white colonies with a smooth outline and a white spot in center. It grows as well on bottom of dish as on surface of agar. On Lactose Litmus Agar it forms branched white colonies. It produces no lactic acid. (See plate.)

FORM No. 17.

Obtained from Gregory & Dobbins' livery barn. This form is fairly abundant.

Morphology. A diplococcus $\frac{3}{4}$ " in diameter. *

Biological Characters. A non-liquefying, non-motile aerobic diplococcus. In Bouillon it produces turbidity and forms a white sediment in the bottom of tube. A white ring forms on tube at surface of liquid. On Agar Streak it forms a slick, red colored growth along streak. In Gelatine Stick culture it grows only on surface, is of a pink color and does not liquefy the gelatine. On Agar Plate it forms small white colonies. The growth is very slow. On Lactose Litmus Agar no change was produced in litmus, showing no lactic acid. It does not grow on Potato.

FORM No. 18.

Obtained from Godman's livery barn.

Morphology. A small micrococcus about $\frac{1}{6}$ " in diameter.

Biological Characters. A non-liquefying, non-motile, aerobic micrococcus. In Bouillon it produces considerable turbidity and forms a white ring on tube at surface of liquid; it also forms a white precipitate in bottom of tube. On Potato it forms a raised granular cream-colored growth along streak. In Gelatine Stick it produces a white convoluted growth on surface, and does not liquefy the gelatine. On Agar Streak it forms a milk white growth with irregular outline. On Agar Plate it produces pale white luxuriant colonies with a smooth outline. On Lactose Litmus Agar the colonies are small and white, producing considerable lactic acid.

HAVE THE COMMON YEASTS PATHOGENIC PROPERTIES?—AN EXPERIMENTAL STUDY. BY KATHERINE E. GOLDEN.

Yeasts have always been considered as purely saprophytic organisms, and not supposed to be parasitic in any sense; but, in the light of some recent experiments, this classification would seem to need reconsideration. These experiments indicate not only that some yeasts are parasitic, but that they are also pathogenic. These results are not at all at variance with developments made in the study of other organisms, as many bacteria which at first were supposed to be saprophytic

have developed parasitic properties; this being brought about through a course of adaptation, which has enabled them to exist under the changed conditions. There are other bacteria possessing pathogenic properties which can be treated in such a manner as to cause them to lose their virulency, among these a notable one being anthrax, which when carried through a course of gelatine cultures is no longer pathogenic. The pathogenic properties may be restored, however, by appropriate treatment, such as cultivation at the body temperature in specially prepared media. Of course, the conditions for a saprophytic mode of life are more generally met with than those for the development of parasitic life, so that it is presumable that most organisms become adapted to them.

About twenty years ago yeast was used in water to spray plants in green-houses for the purpose of getting rid of insect pests.* This treatment was based upon the belief that the yeast entered the body of the insect and produced a growth which was fatal. As pure yeast was not used, and as yeasts usually have associated with them bacteria and molds, the use of yeast for such purposes is not conclusive in proving it to be pathogenic.

Somewhat later a yeast, *S. Allii*, was grown on the bulbs of onions, and caused them to rot by reducing them to a gelatinous condition,† during which time a powerful odor was emitted by them. Bacteria were also found in conjunction with the yeast in the onions.

In recent years, since accurate methods have been devised for the separation of the various species and varieties of yeasts, a more definite knowledge has been obtained of their properties. It has been determined that while most of them possess the property of exciting alcoholic fermentation, that, aside from this, they differ widely in the formation of other products that accompany the fermentation. For example, two species that were found on the fruit of *Ilex aquifolium*, though having the same habitat, gave different products, the one (*S. ilicis* Grönlund) gave a disagreeable, bitter taste to wort, while the other (*S. aquifolii* Grönlund) gave a disagreeable, sweet taste. Of two ellipsoid species studied by Will, the one gave a rough, bitter after-taste, while the other imparted a disagreeable, aromatic taste during the fermentation, and a bitter, astringent after-taste to wort. Then of two species studied by Hansen, one (*S. Pastorianus* I.) gave a disagreeable, bitter taste and unpleasant odor to wort, while the other (*S. anomalous*) gave an ethereal, fruity odor. One might go on at length giving examples of the differences in the products of yeasts, but from what has been given, it can be seen that the products differ widely, and that it is highly probable that some of these

*Hagen, H. A., "Nature," Vol. XXI, p. 611. 1880, April.

†Sorokin, N., Jour. Roy. Micr. Soc., 1889, Pt. I.

various products might be of a toxic character, and also highly probable that if these yeasts were growing vigorously and metabolic activity high, these toxic substances might cause injurious effects either locally or constitutionally in the animal body.

A somewhat common opinion in regard to the yeasts is that when taken into the stomach in bread not cooked sufficiently they set up a fermentation, generate gas, and thus cause great discomfort, though the same kind of gas when taken in soda water seems to have a rather soothing effect. Then this opinion does not seem to prevail in regard to the use of beer or other fermented drinks, though there is no question in regard to the presence or vitality of the yeasts in these beverages.

To determine the effect of yeasts taken into the stomach, two rabbits were placed in a cage in the laboratory where they could be observed conveniently. They were kept over night without any food, and in the morning were given two compressed yeast cakes. These they refused to eat, presumably from their behaviour objecting to the odor. The yeast was then smeared on sugar beet, which they ate. No apparent result followed. After two days about two grams of a pure culture yeast were smeared on sugar beet, which was fed them, after which a week was allowed to intervene. Then, at intervals of two days, each rabbit was given a dry yeast cake, until each one had eaten five cakes. The dry cakes were eaten with avidity, being preferred to the sugar beets, their usual food. At the end of this treatment the rabbits were still healthy, had apparently experienced no discomfort from the unusual addition to their diet, and showed no symptoms of disease. After two days one was chloroformed and then examined, to determine if there were any internal lesions. There proved to be none, all the organs being in their normal, healthy condition. During this examination inoculations were made from the various parts of the intestinal tract—cardiac portion of stomach, pyloric portion of stomach, duodenum, jejunum, ileum, caecum, anterior colon, posterior colon—into sterilized bouillon and wort.

During the time the experiment was in progress, inoculations were made daily into sterilized bouillon and wort from the discarded portions of food which had passed through the intestinal tract. Out of those cultures in wort seven developed yeast alone, seven developed yeast and mould, and two developed mould alone. In conjunction with two of the yeasts was a red yeast which occurs in the air in the laboratory. All of the cultures in bouillon, but one, had a bacterium, resembling the "thrix" forms. An inoculation into bouillon and wort was made in each case from the same material, the bouillon being neutral, the wort acid. The yeasts and mould developed in the wort, but not in the bouillon, whereas,

the bacterium developed in the bouillon, but did not appear in the wort. The organisms in both media were very slow in developing, the first appearance of growth being in about five days, some taking even six and seven days; and in the case of the yeast the fermentation was weak. But in most cases the fermentation lasted for over three weeks.

To test the effect of yeast when introduced into the circulation of animals, pure culture yeasts were used, one separated from a moist yeast cake, one from a dry yeast cake, and the third a wild yeast obtained from the surface of plum. Ten drops from a four days' culture in wort of each yeast were injected into the posterior branch of the main vessel of the ear of three rabbits. These were kept under constant observation, but showed no ill effects from the introduction of the yeast.

Another test was then made upon two different rabbits, and upon two guinea pigs. The yeasts used for the rabbits were a wild one from the surface of persimmon, and one from a moist yeast cake, but a different yeast from the one used in the first experiment. The yeasts used for the guinea pigs were one from the surface of grape, and one from a moist yeast cake, also different from the two previous yeasts. The inoculations in the rabbits were in the vessel of the ear, but those of the guinea pigs were intra-peritoneal. The following day the guinea pigs were slightly sore in the region of the puncture of the hypodermic needle, but that wore off in a short time, and no other ill effects were experienced by any of the animals.

For the next experiment twenty-two different yeasts were grown at the body temperature ($37\frac{1}{2}^{\circ}$ C.) in order to select from them the ones growing most vigorously. These proved to be two wild ones, one from apple, the other from guava, and two cultivated ones, one from beer, and one from a moist yeast cake. One of the yeasts was injected into the ear of a rabbit, a second into the ear of a guinea-pig, while the third and fourth were subcutaneous, into the abdominal wall of guinea-pigs. No ill effects followed the inoculations.

After two days sterilized bouillon and wort were inoculated with blood from the ear of each animal, but in all cases remained sterile. In one tube of wort, in which a large drop of blood had been placed, a few dead yeast cells were found, but no growth took place, indicating that the yeast must have been destroyed in a short time.

The results of the experiments agree in the main with those of Neumayer,* except that he claims that an injury to the animal may always be expected if a fermentable substance be taken at the time the yeasts are. He also claims that when yeasts are grown at a high temperature, abnormal fermentation products

* Neumayer, J. *Centralb. für Bakt. und Parasitenk.*, Bd. XIII, 1893, p. 611.

are formed which may be injurious, this being true for both wild and cultivated yeasts, but that the normal products of fermentation or the multiplication of the yeast cells are not injurious.

Busse* has found a yeast which causes a chronic pyæmia. From its resemblance to *Actinomyces* he gave the disease the name *Saccharomycosis hominis*. The course of the disease, as outlined, is that the yeast falling upon the body increases and causes a local change, this eventually leading to formation of pus and general inflammation. The yeast causes the death of white mice, the blood of which is found to contain numerous yeast cells.

Rabinowitsch,† out of fifty different varieties of yeasts, obtained seven pathogenic ones, which, when injected subcutaneously into mice, rabbits and guinea-pigs, caused their death. It is claimed in this case that the fatalities were due to the rapid multiplication of the yeast cells in the body, and not to any products of fermentation. The yeasts seem to be different from the pathogenic ones of other observers.

The only reasonable conclusion which can be drawn in regard to these varying results is that different species or varieties of yeast were used, these different yeasts having very different products. The writer used only common yeasts, such as are being taken into the system through various sources, from time to time. Though the pressed yeasts, when used in bread, are killed, the products are taken into the system, and all the others used would be taken into the system alive, as they occurred on the skin of fruits and in beer.

The first set of experiments indicate that yeast, when taken into the stomach of rabbits, causes neither discomfort nor lesions in any organ, even when a fermentable substance be eaten at the same time. They also indicate that certain organisms—yeasts, bacteria and moulds—can pass through the intestinal tract without being killed, though from the slowness of growth and the weakness of the fermentation, their vigor must be somewhat impaired.

The second set of experiments indicate that of the common yeasts those used possessed no toxic properties for rabbits or guinea-pigs, neither did they multiply when introduced into the animal body, and in the case of four of them, they must have been destroyed within 48 hours, though these same yeasts were very vigorous at the same temperature outside the body.

* Busse. *Centralb. für Bakt. und Parasitenk.*, Bd. XVII, 1895, p. 719.

† Rabinowitsch, L. *Centralb. für Bakt. und Parasitenk.*, Bd. XVIII, 1 Abt., 1895, p. 590.