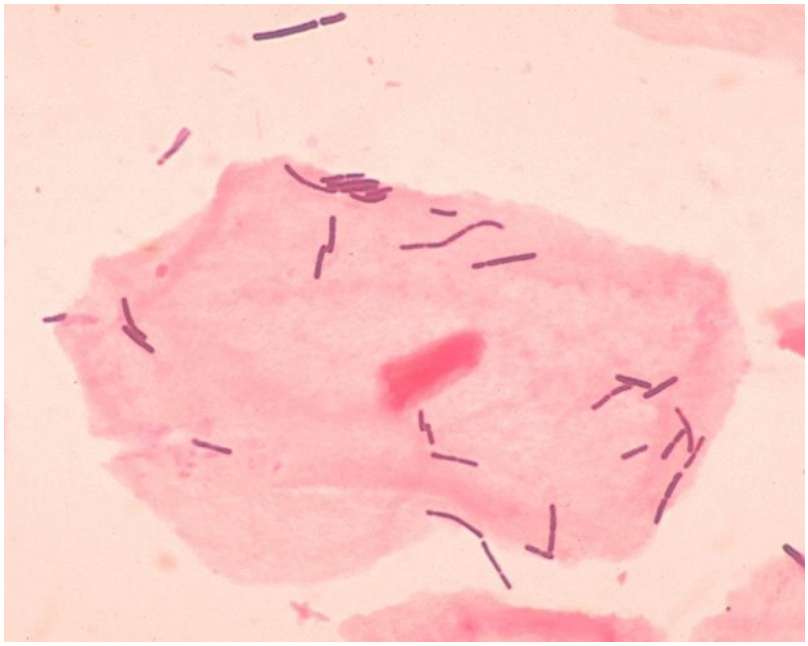
Can probiotic lactic acid bacteria protect the intestines against pathogens?

Billions of microorganisms colonise the human digestive tract. However, these microorganisms can have negative as well as positive effects on human health. Nutrition scientists from the Max Rubner-Institut (MRI) in Karlsruhe are investigating how human pathogens and probiotic bacterial strains interact with each other in the human gastrointestinal tract. Are probiotic bacteria in yoghurt or in pickled vegetables, for example, able to reduce the health risk posed by pathogenic bacteria? Space is at a premium and the intestinal colonisers need to elbow their way to the top.



Lactic acid bacteria under the microscope (rod-shaped structures)
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During a trip across Bulgaria in the early 19th century, Ilya Ilyich Mechnikov, who was later awarded the Nobel Prize, discovered that sour milk products can promote human health. He met peasants in the Bulgarian mountains who were much older than the average and he soon discovered that yoghurt was responsible for the peasants' unusually long lifespan. Over the last few decades, scientists have described numerous lactic acid bacteria strains in dairy products, fermented sauerkraut and other sour fermented foods that have a beneficial (probiotic) effect on human health. For example, Lactobacillus and other lactic acid genera are able to give pathogenic bacteria such as Listeria and Staphylococcus a hard time. "How do they do this?" asks Dr. Claudia Guigas from the Institute of Microbiology and Biotechnology at the Max Rubner-Institut (MRI) in Karlsruhe. "We hope to find an answer to this question by concentrating on the ability of probiotic and pathogenic bacterial strains to attach to intestinal cells."

Competition in a turbulent environment

The human digestive tract is home to 10 to 100 billion bacteria (this is more than the total number of cells in the human body). “In the last few years, researchers around the world have provided increasing evidence for the assumption that the complex intestinal flora interacts with the human organism on many different levels,” said Prof. Dr. Bernhard Watzl, head of the Institute of Physiology and Biochemistry of Nutrition at the MRI. “Metabolic disorders such as diabetes or fatty liver are closely associated with the composition of the intestinal flora. In addition, microorganisms also have an effect on the human immune system.” Researchers from a broad range of different disciplines are therefore interested in obtaining in-depth insights into the interactions between the complex bacterial communities in the human intestines and their effect on the human organism. The researchers are also investigating the effects of probiotic bacteria on human health. However, in order to be able to understand the effects of microorganisms on human health, researchers first need to concentrate on basic aspects.

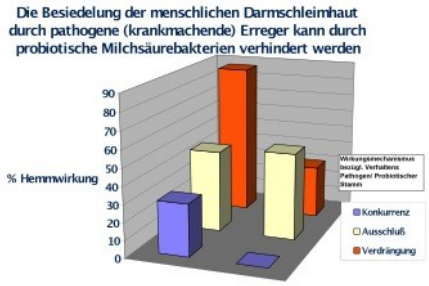
All bacteria strive to find docking sites on the surface of the intestinal wall to avoid being flushed away and excreted. “We use in-vitro cultures of intestinal cells to test whether potentially probiotic bacteria are able to successfully compete with pathogens for access to such attachment sites,” said Guigas. Probiotics have been found to have a plethora of effects in the human body. However, the probiotic bacteria need to be able to adhere to the intestinal cells in order for such mechanisms of action to have an effect. A couple of years ago, Guigas and some of her colleagues tested bacterial cultures from different types of yoghurt in order to find out whether the yoghurt had the alleged positive effect on human health. “Initially, we focused on two major aspects,” said Guigas, who is a nutrition scientist and zoologist. “Are the allegedly probiotic bacterial strains able to survive the ferocious conditions of the stomach and are they subsequently able to adhere to intestinal cells?” Bacteria obviously have to survive the acid conditions in the stomach in order to subsequently be able to colonise (at least temporarily) the human intestine and exert their health-promoting effect.

Guigas used probiotic bacterial strains which were isolated from various commercial yoghurts by a microbiology colleague. The researchers exposed these strains to different acid and alkaline conditions in a process known as in-vitro digestion. They found that all probiotic strains tested were able to survive the simulated passage from the stomach to the intestines. The researchers then used the HT-29 cell culture model to carry out in-vitro adhesion experiments to determine the

number of bacterial cells that remain attached to the intestinal cells following an incubation time of two to four hours and a washing step.

A fight in the arena

"We found that the probiotic bacterial strains adhered quite well to the intestinal wall," said Guigas summarising their findings. Guigas and her colleagues then went on to investigate the adhesive ability of bacteria of less well known foods such as Kenyan dairy products or sour fermented Nepalese vegetables. These adhesion studies led Guigas to the interesting question as to whether probiotic lactic acid bacteria are able to prevent or at least reduce the ability of pathogenic bacteria to colonise the human intestinal mucosa.



Number of pathogens (given in %) that grow on intestinal cells in a cell culture dish when two different probiotic bacterial strains are incubated simultaneously (lilac), probiotic bacteria are cultivated following the initial colonisation of the culture dish with pathogens (yellow) or when probiotic bacteria are allowed to colonise the culture dish before pathogens are added (orange).

Guigas carried out several experimental series involving the aforementioned in-vitro cell culture model in which probiotic strains were allowed to fight pathogenic ones as if they were in an arena. "I wanted to find out whether the presence of probiotic bacteria affected the number of pathogens that are able to adhere to the intestinal cells," said the researcher. She always tested a probiotic strain against a pathogenic one and determined the number of pathogenic bacteria that were bound to the intestinal cells at the end of the experiment. She compared this number with the number of bacteria of the same pathogenic strain that were able to adhere to the intestinal cells in the absence of priobiotic bacteria. Did the presence of probiotic bacteria lead to a reduction in the number of pathogenic bacteria bound to intestinal cells? The experiments showed that probiotic bacteria are able to prevent pathogens from attaching to intestinal cells grown in Petri dishes. The experiments also showed that probiotic bacteria are able to displace pathogens that have already attached to the cells. Depending on the experimental conditions and bacterial strains used, the probiotic bacteria investigated were able to reduce the adhesion of pathogens by up to fifty percent. It is worth noting that this percentage only applies to in-vitro experiments. The human intestine is coated with a thick mucosal layer that is characterised by different gradients of nutrients, oxygen and antimicrobial peptides. Guigas' experiments do not provide information as to whether probiotic bacteria that are principally able to adhere to intestinal cells, are able to cope with this natural environment. In addition, the researchers will also have to test combinations of different probiotic and pathogenic microorganisms in order to take account of the large number of different microorganisms that colonise the human intestinal tract. Little is yet known about the functional complexity of the microflora of the human intestines.

Much more research is still needed

It also appears that other probiotic mechanisms of actions of lactic acid bacteria depend on more aspects than previously assumed. In a recently published paper, Watzl and his team showed that the Lactobacillus casei strain, which is regarded as a probiotic strain and is used in yoghurt, does not have the expected stimulating effect on the human immune system. Prior to Watzl's paper, scientists in other papers had put forward the hypothesis that the bacteria have their greatest effect in patients with a low activity of what are known as natural killer cells. Natural killer cells are the first line of defence against viruses or tumour cells and it was assumed that probiotic bacteria increased the effect of these cells. However, Watzl and his team were unable to confirm that the bacteria increased the activity of natural killer cells. "The use of probiotic bacteria for improving human health is an interesting and highly promising approach. However, at present we do not know which bacterial strain has a positive effect on which kind of person and under which conditions. Research into the benefits of probiotic bacteria is just starting."

Further information:

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