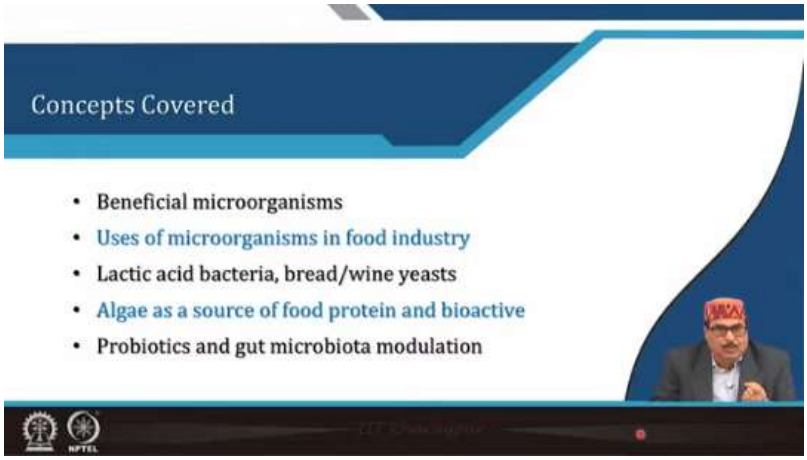
FOOD SCIENCE AND TECHNOLOGY

Lecture35

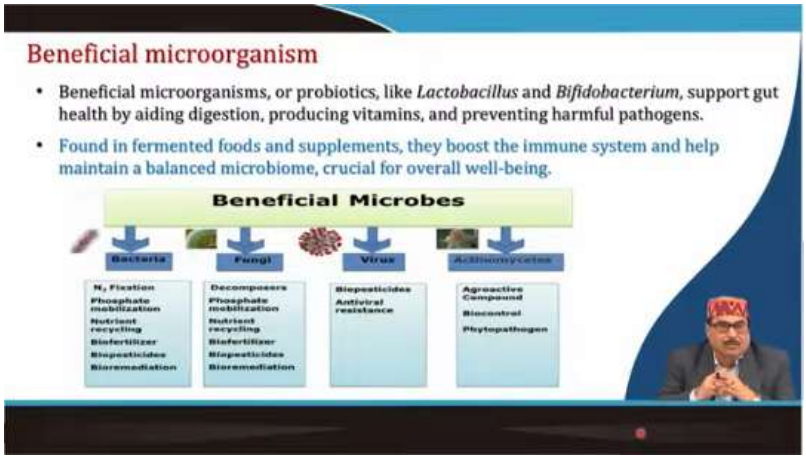
Lecture 35: Beneficial Microorganisms

Hello everyone. Namaste.

We are in the last lecture of module 7, which is lecture 35. In this lecture, we will talk about beneficial microorganisms for the next half an hour or so.

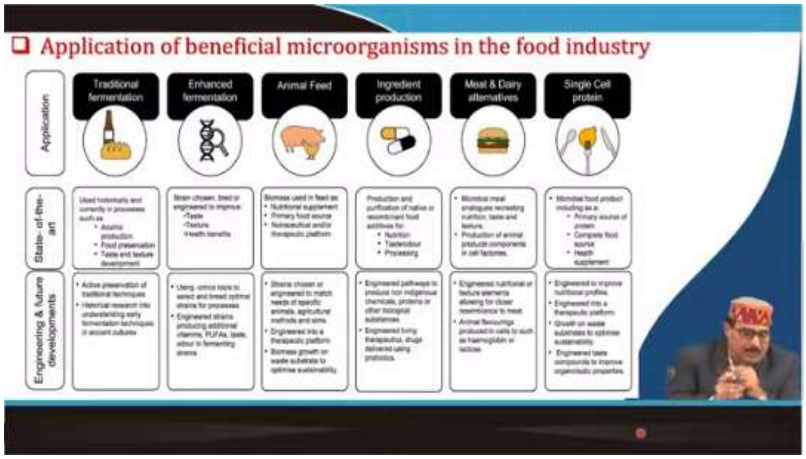


We will discuss what the major beneficial microorganisms are, microorganisms in food industries, particularly lactic acid bacteria, bread or wine yeasts. Then, we will discuss algae, a food protein source, and bioactive compounds. And finally, we will talk about probiotics and gut microbiota modulation.



So, let us discuss the beneficial microorganisms and why and how they benefit us. So, the beneficial microorganisms are probiotics like Lactobacillus and bifidobacterium. They support gut health by aiding digestion, producing vitamins, and preventing harmful pathogens. These beneficial microorganisms are found in fermented foods and supplements. They boost the immune system and help maintain a balanced microbiome, which is crucial for overall well-being. Beneficial microorganisms may be bacteria, fungi, viruses, or actinomycetes. They are beneficial for soil health, like bacteria involved in nitrogen fixation. So, there is phosphate mobilization, nutrient recycling, etcetera. Fungi are also decomposers for phosphate mobilization. So, in agriculture, in food processing, and in our nutrition and health, there are several microorganisms which are beneficial and used for various purposes. Here in this chart, the application of beneficial microorganisms in the food industry is described.

So, let us talk about applications like traditional fermentation. In this, the beneficial microorganism state of the art is used historically and currently in processes such as alcohol production, food preservation, and taste and texture development. The engineering and future developments in these traditional fermentations may include active preservation of traditional techniques or historical research into understanding early fermentation techniques in ancient cultures, etcetera, and how they can be modified, improved, and applied in present-day situations or the future. Then, enhanced fermentation like strains. Here, in this case, strains are chosen, and their bread is engineered to improve the taste, texture, and health benefits of the food.



Engineering and future developments in this area involve using omics tools to select and breed optimal strains for processes, engineered strains producing additional vitamins. Polyunsaturated fatty acids, taste, odours, etcetera, are present in fermenting strains and, therefore, improve the quality, texture, safety, etc., of the fermented foods. In animal feed, biomass is used as a nutritional supplement, primary food source, nutraceutical, and/or therapeutic platform. Here the strains are chosen to be engineered to match the needs of specific animals, agricultural methods and aims, engineered into therapeutic platforms, biomass growth on waste substrates or optimized sustainability, etcetera. Then, in ingredient production, beneficial microorganisms also have a great history of being used, and the state of the art here is the production and purification of native or recombinant food additives for proper nutrition, proper taste and odour, and the proper processing environment. Many times, microorganisms are used as a processing aid. So, the future development or engineering environment in this area may include engineered pathways to produce non-indigenous chemicals, proteins, or other biological substances, engineered living therapeutics, drugs delivered using probiotics, etcetera which may further improve the ingredient characteristics and qualities, then in the meat and dairy alternatives, this industry that is there is a lot of scopes, and even now so many microbial use of the microorganism in that is the modifying the characteristics of the meat and milk products etcetera like microbial meat. cultured meat we are now getting, which is analogous to meat recreating nutrition, taste and texture, even the production of animal product components in cell factories, etcetera. Then they are engineered nutritional or textured elements allowing for the closer resemblance of meat or animal flavourings produced in cells, such as haemoglobins or lactose, etcetera. These are the feature developments you can go to where all beneficial microorganisms have a great role. Single-cell protein is a very popular microbial food product, including as a primary source of protein, complete food source or health supplement. Obviously, in future developments or engineering involvement, it

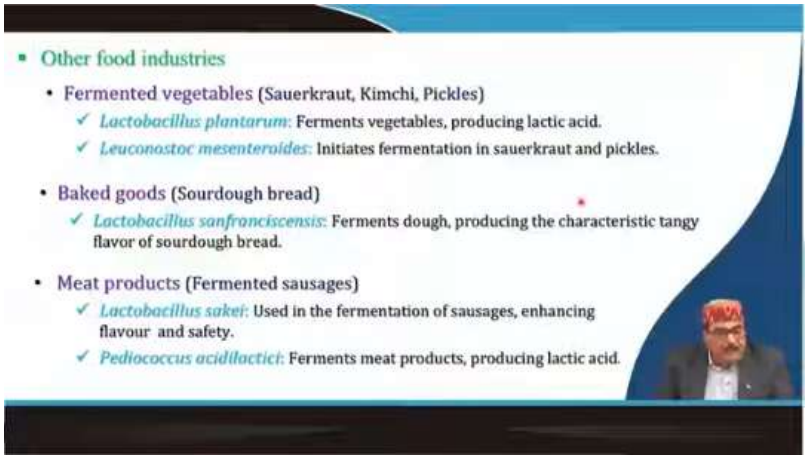
includes that they are engineered to improve nutritional profiles and engineered into a therapeutic platform. Growth on waste substrates to optimize sustainability and engineered taste compounds to improve organoleptic properties, etcetera. So, these are some of the applications of beneficial microorganisms in the food industry.

So, let us take one or two quick examples, particularly in the dairy industry. Here, the dairy industry utilizes lactic acid bacteria, which are very popular, Lactobacillus, Lactococcus, Leuconostoc, Pediococcus, Streptococcus, etcetera, and these bacteria are used for producing various types of fermented products. These microorganisms ferment lactose into lactic acid, which coagulates milk proteins, creating thicker textures in products like yogurt and cheese. The lactic acid bacteria lower the product's pH. Therefore, this limits harmful microbial growth and enhances safety and shelf life. To meet rising consumer demands, industrial dairy fermentation ensures product consistency, safety, and desirable sensory qualities. Microbial fermentation enhances dairy product variety and nutritional value and contributes significantly to the economic strength of the dairy sector, dairy industry. Good examples, in this case, include *Lactobacillus bulgaricus*, which ferments milk to produce yoghurt; *Streptococcus thermophilus*, which works on lactobacillus to produce yoghurt; and cheese *Lactobacillus casei*, which is used in cheese and fermented milk products. So, there are several examples of the benefits of using beneficial microorganisms in the dairy industry for various purposes.

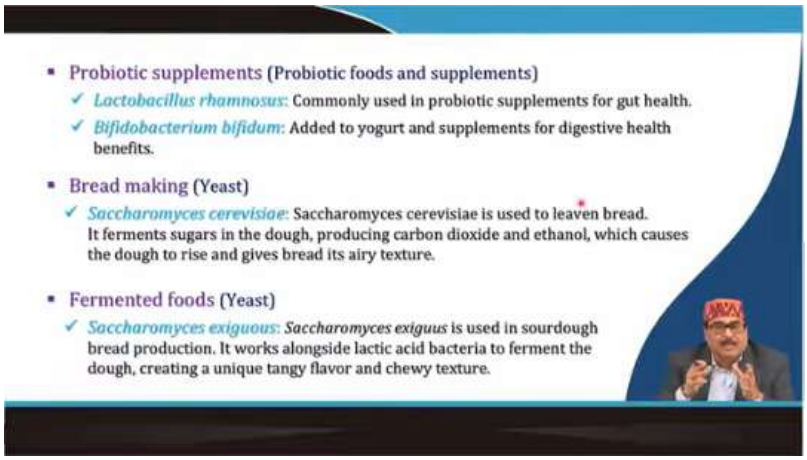
In the alcoholic beverages producing industries, the yeast *Saccharomyces cerevisiae* is used for alcohol production. Saccharomyces cerevisiae converts sugar into alcohol which is crucial for brewing beer, wine and spirits. Wine and beer are fermented, spirits are fermented, and beverages are distilled again. So, they are distilled after fermentation, which becomes whisky, etcetera, but here again, the main process is fermentation, where yeast is used. Large-scale fermenters enable efficient, consistent alcohol production, etcetera. Then, acetic acid bacteria convert alcohol to acetic acid, turning fermented drinks into vinegar. Then, varied raw materials worldwide showcase microbial adaptability in beverage production. So this is in fermented beverages, which is another major sector where beneficial microorganisms are used.

So, you can see that alcoholic beverage that is, the fermented bottom-fermented yeast is used to produce lager beer like *Saccharomyces parasiticus* or *Saccharomyces bionius*, etcetera. Then, top-fermented yeast is used in the production of ale, that is, *Saccharomyces*

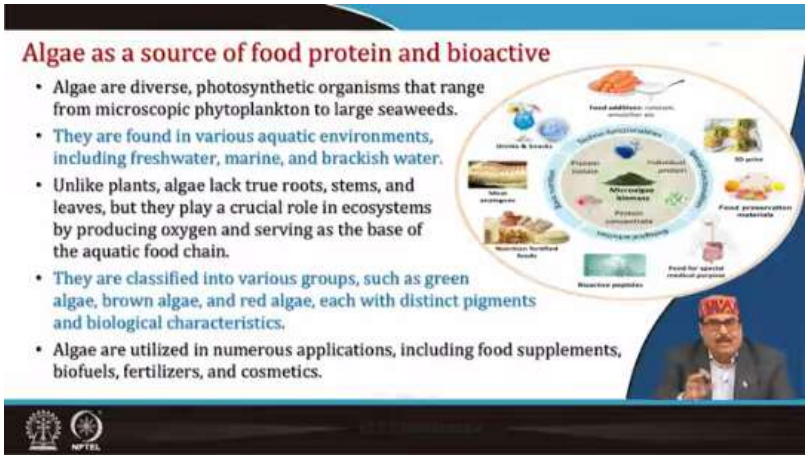
cerevisiae, top-fermenting yeast. Then, unconventional yeast-fermented like *Saccharomyces asbestos, Veterinomyces, Pichia, Hensinospora, Terlospora*, etcetera is used. Then, spontaneously fermented sour beer is used by the *Saccharomyces, veterinomyces*, etcetera is used. Then, non-spontaneously fermented sour is used for acidification, like sour malted lactic acid bacteria, and sour is masked again with lactic acid kettle sour lactic acid bacteria. Sour fermenting uses primary sourcing. Here, yeast is used in a sour fermented mixed starter culture where lactic acid bacteria, yeast, and acetic acid bacteria are used in the sour matured. They are also used like this. Then, non-biological acidification, where, of course, no microorganisms are used. So, you can see that there are a lot of uses, varying the different conditions, etcetera that either yeast or lactic acid bacteria or acetic acid bacteria are used to produce a variety of beverages, particularly alcoholic beverages. In some of the beverages, even non-alcoholic beverages, there are many times probiotic bacteria, etcetera, or other bacteria are used to improve the colour, flavour, taste, etcetera, and shelf life of the beverages.



Then other food industries, like fermented vegetables like sauerkraut, kimchi, and pickles, *Lactobacillus plantarum* ferments vegetables and finally, produces lactic acid, and the pH acts as a shelf-life enhancement. Then *Leuconostoc mesenteroides* initiates fermentation in sauerkraut and pickles. In baked goods like sourdough bread, *Lactobacillus sanfranciscensis* ferments dough and produces the characteristic tangy flavor of sourdough bread, and in meat products like fermented sausage, etc. *Lactobacillus sakei* is used to ferment sausage, enhancing flavour and safety. *Pediococcus acidilactici* ferments meat products, producing lactic acid, etc. Again, large examples of the fermentation process are the food industry, bakery industry, alcohol-making industry, grain processing industry, etc.

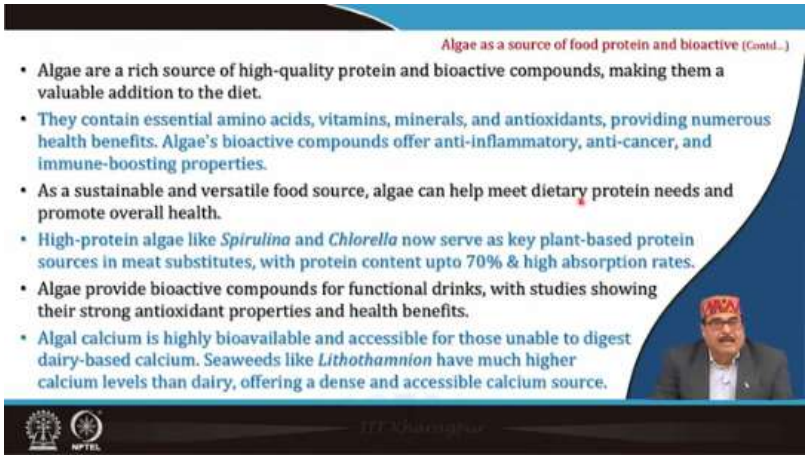


There are probiotic supplements, like *Lactobacillus rhamnosus*, commonly used in probiotic supplements for gut health, improving gut health. *Bifidobacterium bifidum* is added to yoghurt and supplements for digestive health benefits. In bread-making, the very popular saccharomyces cerevisiae is used for leavening, giving the leavening effect of yeast leavening. It ferments sugar in the dough, producing carbon dioxide and ethanol, which causes the dough to rise and gives the bread its airy texture, its crumb green texture. Then, fermented food yeast is used, like *saccharomyces exigeris*, in sourdough bread production. It works alongside lactic acid bacteria to ferment the dough, creating a unique tangy flavour and chewy texture.

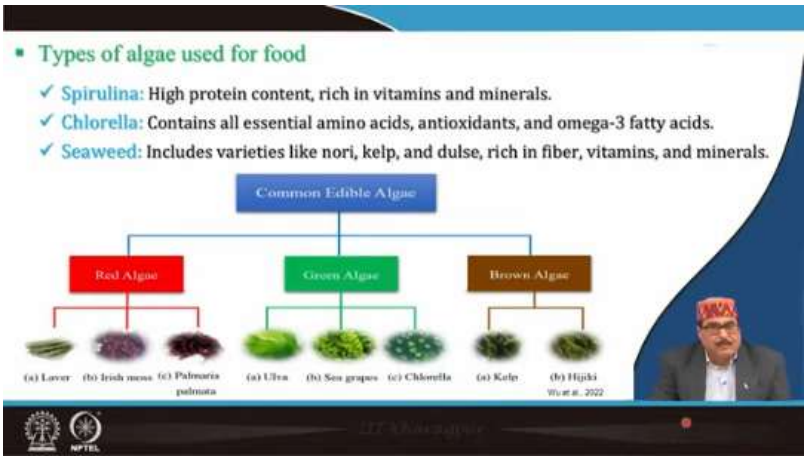


Now, let us discuss algae as a food protein source and bioactive. I hope algae are diverse, photosynthetic organisms ranging from microscopic phytoplankton to large seaweeds. They are found in various aquatic environments, including freshwater, marine, and brackish. However, unlike plants, algae lack true roots, stems, and leaves, but they play a

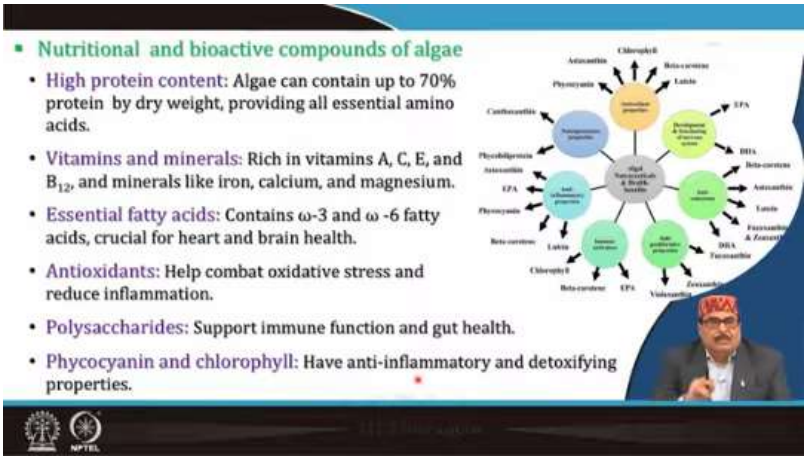
crucial role in ecosystems by producing oxygen and serving as the base of the aquatic food chain. Algae are classified into various groups, such as green algae, brown algae, and red algae, each with distinct pigments and biological characteristics depending on their pigments: red, green, brown, blue, and so on. Algae are utilized in numerous applications, including food supplements, biofuels, fertilizers as well as even cosmetics.



Algae are a rich source of high-quality protein and bioactive compounds, making them a valuable addition to the diet. They contain essential amino acids, vitamins, minerals and antioxidants, providing numerous health benefits. Algae's bioactive compounds offer anti-inflammatory, anti-cancer and immune-boosting properties. As a sustainable and versatile food source, algae can help meet dietary protein needs and promote overall health. High protein algae like spirulina and chlorella now serve as the key plant-based protein sources in meat substitutes with protein content up to as high as 70 per cent, and also have high absorption rates. Algae provides bioactive compounds for functional drinks, and studies show their strong antioxidant properties and health benefits. Algal calcium is highly bioavailable and accessible to those who are unable to digest dairy-based calcium. Seaweeds like *Lithoammonia* have much higher calcium levels than dairy products, offering a dense and accessible calcium source.

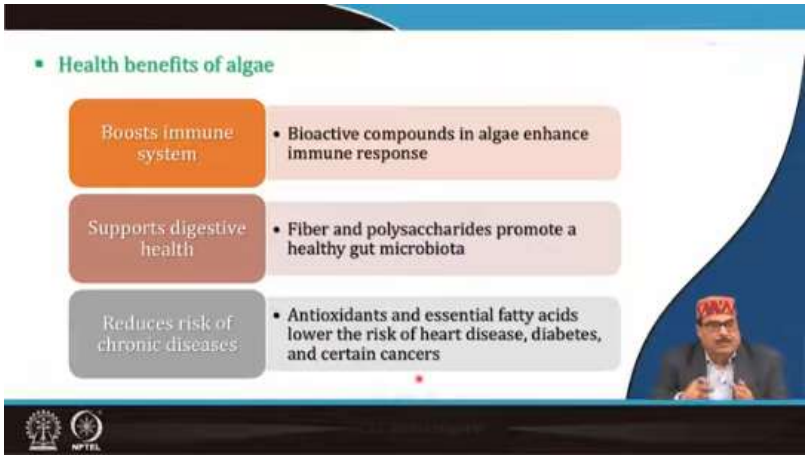


So, the type of algae that is used in food is spirulina, which has a high protein content: it is rich in vitamins and minerals. Chlorella contains all essential amino acids, antioxidants, and omega-3 fatty acids. Seaweeds include varieties like nori, kelp, and dulse, and they are rich in fibre, vitamins, and minerals. Common edible algae include red algae like laver, Irish moss, and porphyria. Green algae like Ulva, sea grapes, and chlorella, and brown algae like kelp and hijiki.

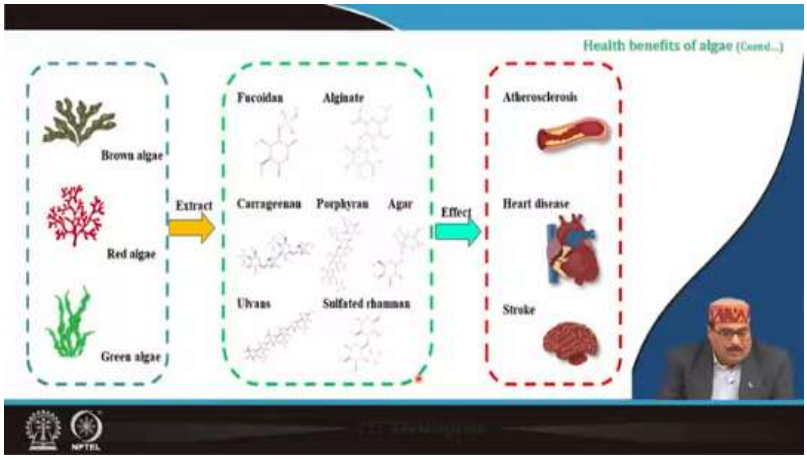


As I mentioned earlier, the nutritional and bioactive compounds in algae are categorized as high-protein foods. They are categorized as high-protein-containing foods. Algae can contain up to 70 percent protein by dry weight, providing all essential amino acids. They are rich in vitamins A, C, E, and B_{12} and minerals like iron, calcium, and magnesium. They contain omega-3 and omega-6 fatty acids, which are crucial for brain and heart health. They contain antioxidants, which help combat oxidative stress and reduce inflammation. They also contain a good amount of high-quality polysaccharides, which support immune

function and gut health. Algae also contain significant proportions of phycocyanins and chlorophylls, which have anti-inflammatory and detoxifying properties.



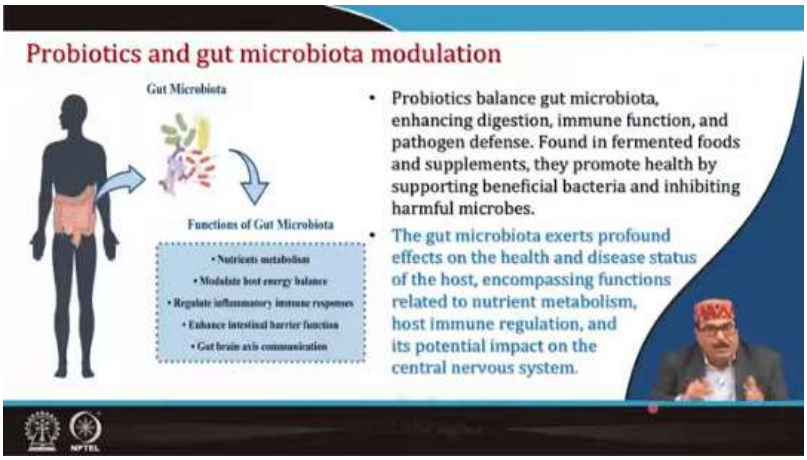
As I mentioned earlier, the health benefits of algae include boosting the immune system, which is enhanced by the bioactive compounds in algae. They enhance the immune response. Also, it supports digestive health, as fibres and polysaccharides present in algae promote healthy gut microbiota. Also, algae reduce the risk of chronic diseases, such as the antioxidants and essential fatty acids present in algae, which lower the risk of heart disease, diabetes, and even certain cancers.



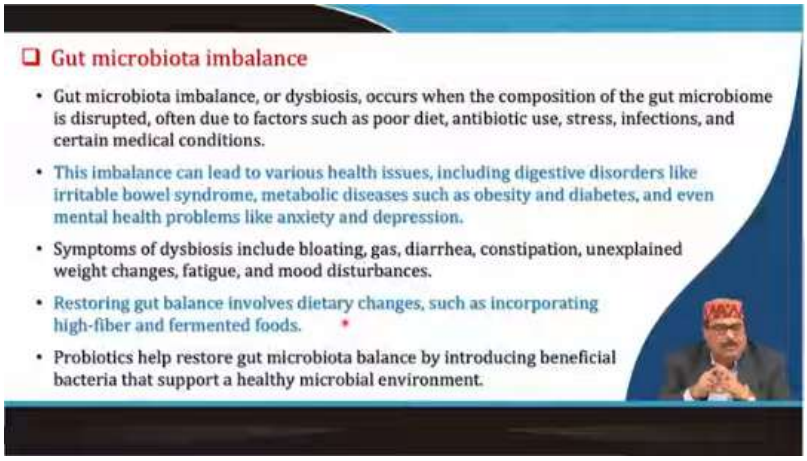
So, both brown algae, red algae, and green algae have various components, such as fucoidan, alginate, carrageenan, porphyra, agar, ulvans, and sulfonates. These components can be extracted and prepared using the extracts of these materials, and then they can be used in the formulation of various foods, etc. And obviously, they help with diseases like

atherosclerosis, heart disease, strokes, etc., improving these conditions and removing adverse effects. So, they provide health benefits.

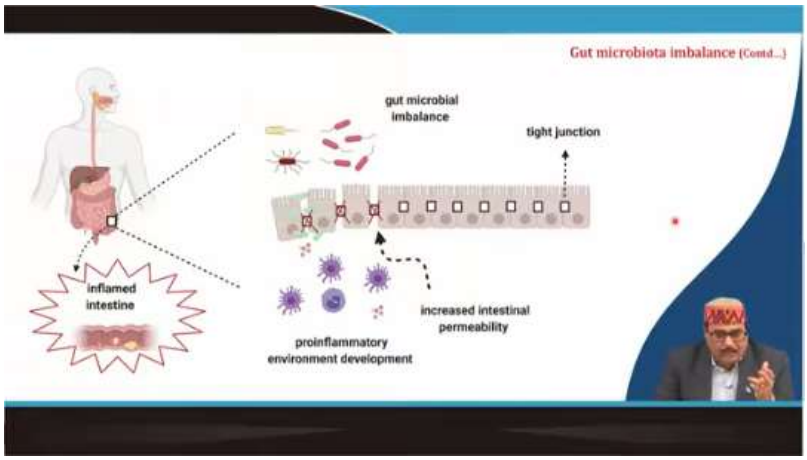
Then, let us briefly talk about the application of beneficial algae to the food industry. Here, they are used as a nutritional supplement. As I told you, Nutella, Spirulina and Chlorella are popular as dietary supplements due to their high protein content and also due to the content of their essential amino acids, vitamins and minerals. They are added to foods to enhance their nutritional value, including vitamins, minerals and omega-3 fatty acids. The algae are used in animal and fish feed to improve nutrition and health, leading to better growth and disease resistance. Algae serve as a sustainable and environmentally friendly protein source, potentially reducing reliance on traditional animal-based proteins, and then algae-derived substances like agar, carrageenan and alginates are used as thickeners, stabilizers, gelling agents, etcetera in various food product formulation and processing.



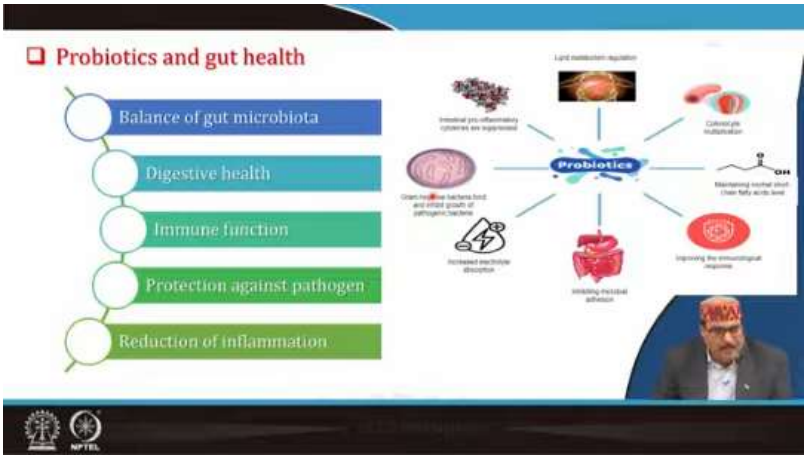
Now, let us talk about probiotics and gut microbiota and the probiotics that balance the gut microbiota, enhancing digestion, immune function and pathogen defense. These probiotics are commonly found in fermented foods and supplements. So, they promote health by supporting beneficial bacteria and inhibiting harmful microbes. The gut microbiota exerts profound effects on the health and disease status of the host. It profoundly affects health and disease status, encompassing functions related to nutrient metabolism, host immune regulation, and its potential impact on the central nervous system. So, you can see here in the figure that microorganisms like gut microbiota are present in the gut, the large intestine. They have functions related to nutrient metabolism, modulate host energy balance, regulate inflammatory immune responses, enhance intestinal barrier function, and gut brain-axis communication. So, these are the beneficial effects of gut microbiota modulation.



So, now let us discuss gut microbiota imbalance. So, gut microbiota imbalance, or dysbiosis, occurs when the composition of the gut microbiome is disrupted, often due to factors such as poor diet. antibiotic use, stress, infections, and certain medical conditions. So, this imbalance can lead to various health issues, including digestive disorders like irritable bowel syndrome, metabolic diseases such as obesity and diabetes and even mental health problems like anxiety and depression. So, gut microbiota imbalance or dysbiosis symptoms include bloating, gas, diarrhoea, constipation, unexplained weight change, fatigue and mood disturbances. So, one must have a proper gut microbiota and restore the gut balance. Restoring gut balance involves dietary changes such as incorporating high-fibre and fermented foods, using more probiotic foods, probiotic bacteria, etcetera. And these probiotics help restore gut microbiota balance by introducing beneficial bacteria that support a healthy microbial environment.

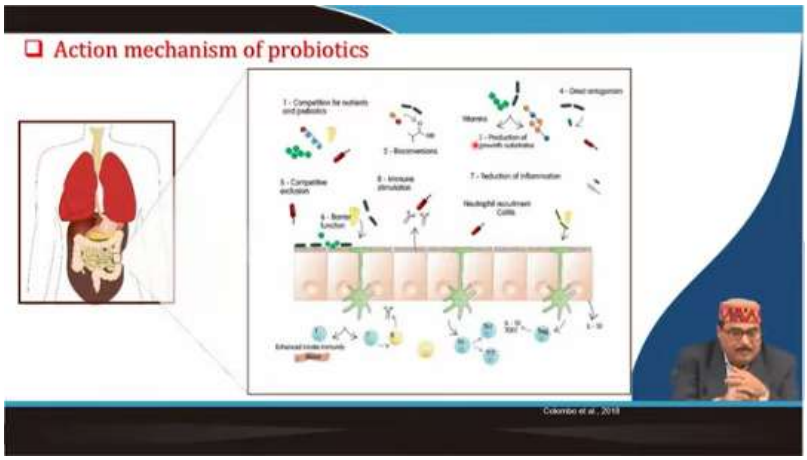


So, here you can see that it has been shown that if there is a gut microbial imbalance, then it causes an inflamed intestine. It results in a prior inflammatory environment may develop. result in gut microbial imbalance and increased intestinal permeability, which can lead to a tight junction. So, you can see the effects of how gut microbial imbalance functions. It may lead to various ones.



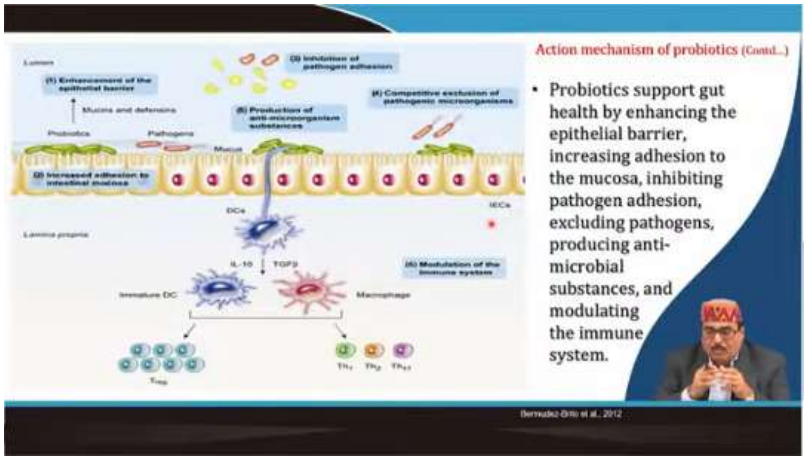
Then, let us talk about probiotics and gut health. These probiotics are beneficial; they balance the gut microbiota, improve digestive health, and enhance immune function. They provide protection against pathogens and reduce inflammation. Probiotics regulate lipid metabolism and colonocyte multiplication. They maintain normal short-chain fatty acid levels and improve immunological response. Probiotics inhibit microbial adhesion, etcetera, and help increase electrolyte absorption. Gram-negative bacteria bind and inhibit the growth of pathogenic bacteria in the intestinal tract. Pro-inflammatory cytokines are

suppressed. So, these are the beneficial mechanisms by which probiotics act and improve and maintain proper gut microbiota balance.

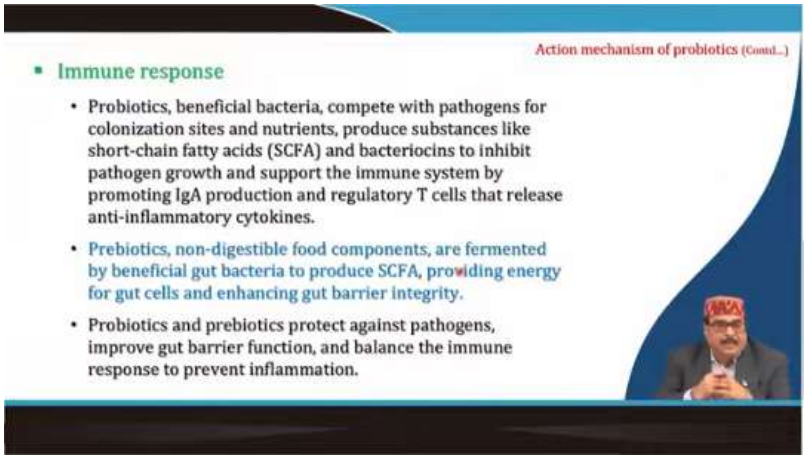


So, here you see the action mechanism of probiotics, like the first thing when these probiotics are present in the gut. There is a competition between nutrients and the prebiotics you are taking. So, there they compete for the nutrients as well as in the prebiotics, and they cause the bioconversion of these nutrients, etcetera. Maybe sometimes they break this and produce beneficial compounds, growth substrates, etcetera, like vitamins and other things. There is also some direct antagonism, which is undesirable substances or undesirable microorganisms that are suppressed. Finally, there is a competitive exclusion, and in this process and they improve the barrier dysfunction, barrier function, barrier properties, etcetera are improved. Then, there is a reduction in the inflammation, and finally, after the reduction in the inflammation, there is immune stimulation, neutrophil recruitment, colitis, etcetera. So, this is the way these probiotics work: there is a mechanism for their working inside our gut, and improving the functions has a better effect.

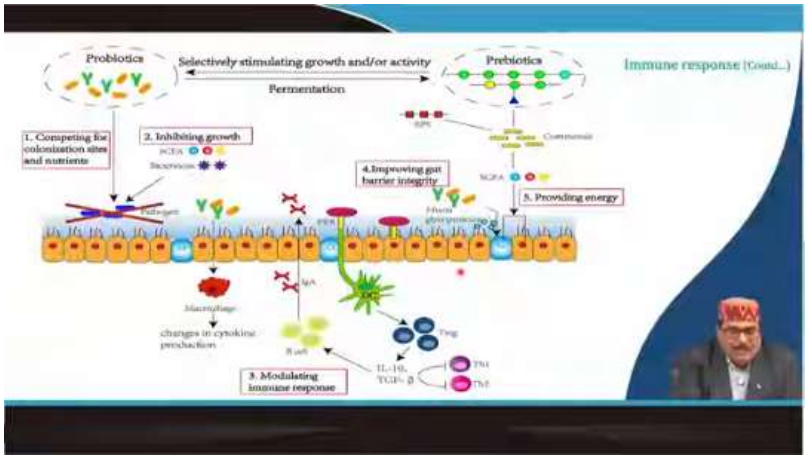
So, probiotics support gut health by enhancing the epithelial barrier enhancement of the epithelial barrier. Increasing the adhesion to the mucosa. Inhibiting pathogen adhesion, excluding pathogens, and producing antimicrobial substances. And modulating the immune system. It is shown in the earlier figure, and similarly, it is shown in this figure as well. You can see that if they enhance the epithelial barrier functions, then there is Inhibition of pathogenic bacteria, competitive exclusion of pathogenic bacteria, production of antimicrobial substances, increased adhesion to the intestinal microflora, etcetera, and modulation of the immune system.



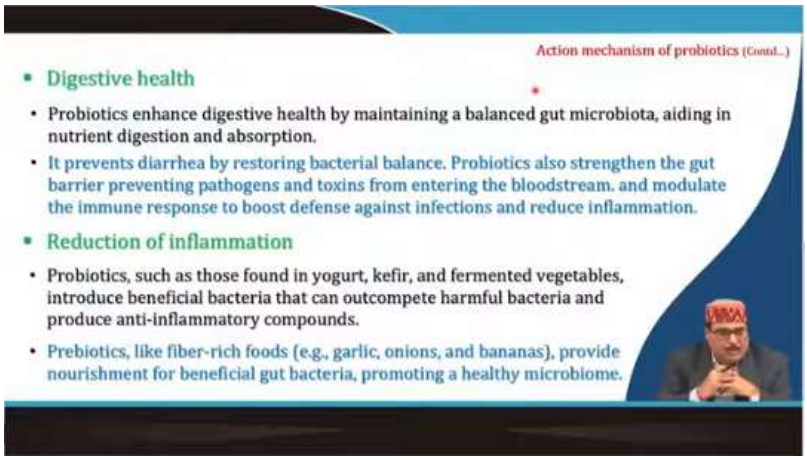
That is how, when you take this way, they provide the action they perform, and then they provide benefits by modulating our microbiota system and the functioning of the gut.



Then, the immune response: probiotic beneficial bacteria compete with the pathogens for colonization sites and nutrients. They produce substances like short-chain fatty acids and bacteriocins to inhibit pathogen growth and support the immune system by promoting IgA production and regulatory T cells that release anti-inflammatory cytokines. Prebiotics are essential food for the probiotics. So, prebiotics are the non-digestible food components that are fermented by beneficial gut microbiota to produce short-chain fatty acids, which provide energy for gut cells and enhance gut barrier integrity. Probiotics and prebiotics protect against pathogens, improve gut barrier functions, and balance the immune response to prevent inflammation.

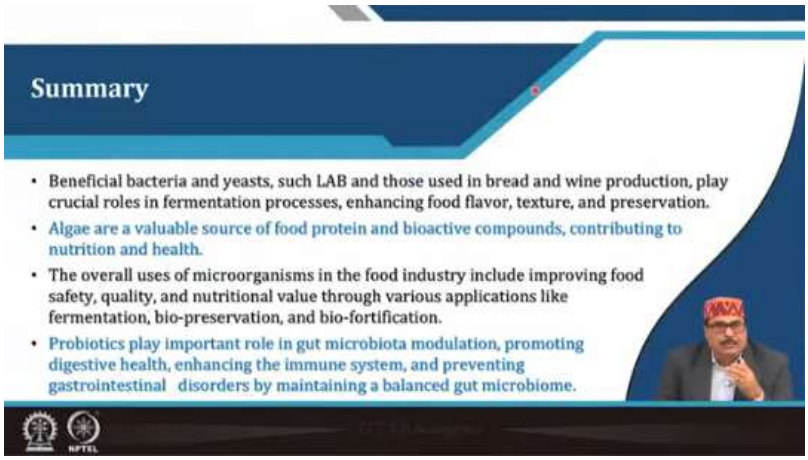


Again, this figure shows how they function and how these probiotics modulate the immune response. There is competition for colonization sites and nutrients. These probiotics compete and, therefore, inhibit growth; they produce starch, fatty acids, bacteriocins, etcetera, and thus, the growth of pathogens is inhibited. After this, they modulate the immune function; the B cells result in IgA production, etcetera, and then they modulate the immune response. Also, the macrophages undergo changes in cytokine production, which improves gut barrier properties, such as modulated mucus, mucin, glycoproteins, etcetera. Then, like prebiotics, they ultimately provide energy by entering cells and supplying it. These prebiotics are used by the probiotics for selectively stimulating growth and activity, and these probiotics can also ferment the prebiotics. So, in this way, they finally regulate and modulate the process.



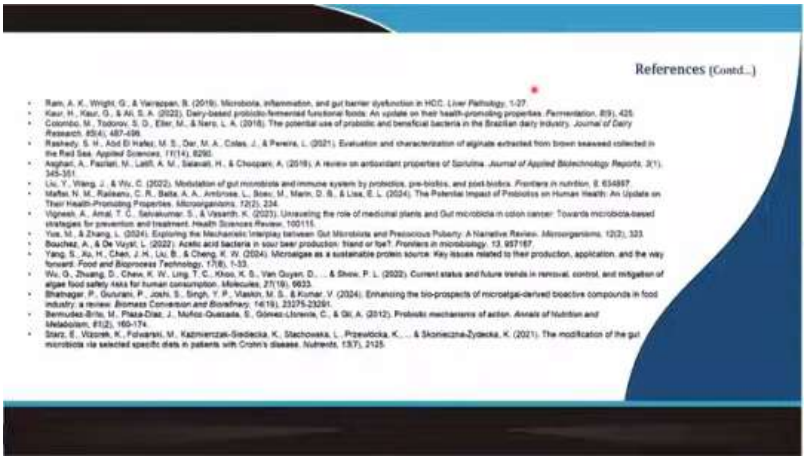
So, probiotics enhance digestive health by maintaining a balanced gut microbiota, aiding in nutrient digestion and absorption. They prevent diarrhea by restoring bacterial balance.

Probiotics also strengthen the gut barrier, preventing pathogens and toxins from entering the bloodstream and modulating the immune response to boost defense against infections and reduce inflammation. So, how is the reduction of inflammation achieved? Probiotics, such as those found in yoghurt, kefir, and fermented vegetables, introduce beneficial bacteria that can outcompete harmful bacteria and produce anti-inflammatory compounds. Prebiotics, like fibre-rich foods, for example, garlic, onions, and bananas, etc. provide nourishment for the beneficial gut bacteria, promoting a healthy microbiome.



So, finally, I would like to summarize this lecture by saying that the beneficial bacteria and yeast, such as lactic acid bacteria and those used in bread and wine production. They play crucial roles in fermentation processes, enhancing food flavor and texture and preserving the food. So, a large variety of microorganisms are used in the food industry for ingredient production, fermented food production, enzyme production, preservative production, and acid production. So, various microorganisms are used, and even algae is one such microorganism, which is used. as a valuable source of food protein and bioactive compounds, and obviously, it contributes to nutrition and health. So, the overall uses of microorganisms in the food industry include improving food safety, quality, and nutritional value through various applications like fermentation, biopreservation, and biofortification. As we mentioned earlier, this biopreservation may also be discussed separately. Various microorganisms are used to preserve foods by producing bacteriocins, etcetera, which are the products of the growth of microorganisms used to control microbial growth. So, probiotics may play an important role in the modulation of gut microbiota, promoting digestive health, enhancing the immune system and preventing gastrointestinal disorders by maintaining a balanced gut microbiome, which is very important. So, one should regularly try to consume a good number of probiotics. Now, even their probiotic capsules,

like probiotic milk, probiotic yoghurt, probiotic dairy, other dairy products, and even probiotic vegetable beverages, are available on the market. So, one should regularly try to have this good because if there is a microbiota gut microbiota imbalance, it may create a lot of disorders. So, one should have a proper gut microbiota.



So, these are the references used in this lecture.

Thank you very much for your patience hearing. Thank you.