Salud, Ciencia y Tecnología. 2023; 3:409
doi: 10.56294/saludcyt2023409

REVIEW

Exploring the Potential of Probiotics as Biocontrol Agent

Exploración del potencial de los probióticos como agente de biocontrol

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Cite as: Sharma SR, Parveen S, Singh J. Exploring the Potential of Probiotics as Biocontrol Agent. Salud, Ciencia y Tecnología. 2023;3:409. https://doi.org/10.56294/saludcyt2023409

Received: 19-04-2023 **Reviewed:** 02-05-2023 **Aceptado:** 14-06-2023 **Publicado:** 15-06-2023

Editor: Fasi Ahamad Shaik

ABSTRACT

Threats from pathogenic microbes could affect the food and agricultural sectors. Pathogenic bacteria have the ability to contaminate food at any stage of the production process. Conventional techniques are frequently employed as microbial control measures, including those utilizing antibiotics, disinfectants, and physical procedures. Many nations have passed rules and regulations banning their usage due to the drawbacks of these technologies, including the formation of resistance, low effectiveness, high expense, and negative impacts on food, health, and the environment. An affordable, ecologically friendly alternative strategy is urgently required to solve these issues. When ingested in sufficient proportions, probiotics are live bacteria that protect the host against pathogens and provide nutritional advantages. Probiotic use in animals reduces zoonotic infections in the gastrointestinal tract (GIT) of animals, preventing the spread of these pathogens through food, according to the food microbiology perspective. In order to improve food safety and healthcare, probiotics have been suggested as an alternative antibacterial method of protection against harmful microbes. With a accentuate the meals and agricultural (livestock and aquaculture sectors) areas, we cover probiotics, their criterion for choosing, their modes of activity, and potential as alternative biocontrol agents in this review.

Keywords: Probiotics; Antimicrobial; Food Safety; Health; Gastrointestinal Tract (GIT).

RESUMEN

Las amenazas de los microbios patógenos podrían afectar a los sectores alimentario y agrícola. Las bacterias patógenas tienen la capacidad de contaminar los alimentos en cualquier fase del proceso de producción. Con frecuencia se emplean técnicas convencionales como medidas de control microbiano, entre ellas las que utilizan antibióticos, desinfectantes y procedimientos físicos. Muchos países han aprobado normas y reglamentos que prohíben su uso debido a los inconvenientes de estas tecnologías, como la formación de resistencias, su escasa eficacia, su elevado coste y sus efectos negativos sobre los alimentos, la salud y el medio ambiente. Para resolver estos problemas se necesita urgentemente una estrategia alternativa asequible y respetuosa con el medio ambiente. Cuando se ingieren en proporciones suficientes, los probióticos son bacterias vivas que protegen al huésped contra agentes patógenos y aportan ventajas nutricionales. El uso de probióticos en animales reduce las infecciones zoonóticas en el tracto gastrointestinal (TGI) de los animales, evitando la propagación de estos patógenos a través de los alimentos, según la perspectiva de la microbiología alimentaria. Con el fin de mejorar la seguridad alimentaria y la atención sanitaria, se han sugerido los probióticos como método antibacteriano alternativo de protección contra los microbios nocivos. Haciendo hincapié en las áreas de la alimentación y la agricultura (sectores ganadero y acuícola), en esta revisión abordamos los probióticos, sus criterios de elección, sus modos de actividad y su potencial como

agentes alternativos de biocontrol.

Palabras clave: Probióticos; Antimicrobianos; Seguridad Alimentaria; Salud; Tracto Gastrointestinal (TGI).

INTRODUCTION

Agriculture has been crucial to the advancement of human civilization. A rise in agriculture is necessary to feed a population that is constantly expanding. In the previous 50 years, there has been a five-fold rise in the area under cultivation, and a seven-fold increase in the usage of artificial fertilizers.[1] One of the top goods in the category of beneficial ones is the tomato (Lycopersiconesculentum). Additionally, it is among the most valued and well-liked veggies in the world. Numerous beneficial substances are present in it, including ascorbic acid, lycopene, -carotene, anthocyanin, and others.[2] Research has shown the intestinal the microbe greatly affects our overall health, and it is possible to study how they might be used to treat psychological problems. Through a crucial interaction between the stomach and the brain, changes in the gut microbiota can have an impact on the host's IQ, mood, behavior, autism, and psychological well-being.[3] Brown algae likethesargassumsinicola, the generaascophyllumnodosum, and macrocystispyrifera, as well as a few types of microbes like Pseudomonas and Azotobacter, produce large amounts of sodium alginate (ALG), a polysaccharide. ALG is found in seaweed cell walls as a combination of insoluble calcium, magnesium, potassium, and sodium salts and performs a similar function as cellulose in plants.[4] In order to prevent chronic diseases like hypertension, coronary heart disease, and stroke risk, the World Health Organization (WHO) and Food and Agriculture Organization (FAO) recommend consuming a particular amount of vegetables and fruits everyday. Consumers tend to favor foods and drinks that are readily available, fresh, highly nutritious, and promote good health.[5] The ability of LAB to produce a number of (Organic acids, hydrogen peroxide, and other metabolites in addition for example) bacteriocins) with antibacterial action against undesirable foodborne microorganisms, such as pathogens and spoilers, is another factor that contributes to their long-term utilization in reactions of food and drink. The potential of lactobacilli for biocontrol has been increasingly utilized in recent years to create safe societies that prevent pathogen contaminations and minimize spoilage, thereby reducing the need for chemical preservatives in a variety of food distribution systems, especially in the area of least prepared meals.[6] By mineralizing nutrients and boosting soil fertility, microorganisms can enhance soil health and aid in biocontrol. They can also support plant growth while having no adverse effects on the environment. For food security, improving agricultural productivity is just as critical as enhancing food processing, storage, and preservation methods. Once more, by applying fermentation technology, the microorganisms can be employed to prolong the usefulness of a variety of food goods as well as transform food waste into an edible form.[7] Probiotics in general are said to the Food and Agriculture Organization (FAO) and World Health Organization (WHO), are active, living microbes, when consumed in sufficient quantities, boost the host's health. The most extensively utilized probiotic genera are Lactobacillus and Bifidobacterium, which are included in many functional foods (such fermented dairy products) and nutritional supplements. Consuming probiotics has been linked to a number of health advantages, such as immune system activation, defense against gastrointestinal infections, lowered cholesterol, and anticancer effects.[8] Because Lactobacilli strains simplify the intricate macro molecules via hydrolysis with their hydrolytic enzymes, the nutritional quality may improve during fermentation. The main The characteristics of processed food's lactobacilli species foods include antimicrobial activity, acid and bile acceptance, stomach transit patience, and outside of cell characteristics (such bacterial hydrophobicity, co-aggregation, and auto-aggregation), metabolic products (such as Hydrogen peroxide, peptides that are bioactive, and fatty acids, amino acids, bactericidal and cell wall elements), with the assessment of safety factors like antibiotic resistance.[9] Rocchetti et al.[10] evaluate the intracellular antibiotic qualities of microorganisms that have already been marketed and used in the dairy industry, which is the opposite of the traditional bottom-up method. Dealing with strains that are already acceptable for industrial scale-up is the main benefit of reversing the conventional method. Dahiya et al.[11] evaluate the pertinent research and discuss the findings of recent investigations into the therapeutic antibiotic strains' potency and their impact on psychological problems. Elias et al.[12] examined the bioactive potentials of probiotics and prebiotics, nanotechnology, bacteria, biofloc, and plants for medicine in the prevention and treatment of various vibriosis illnesses while also assessing the drawbacks and prospects for the future. Pop et al.[13] concentrates on the aforementioned factors and shows the probiotics' potential hazards as well as their anti-mutagenic and anti-carcinogenic properties based on scientific data.In order to develop food products more safely and sustainably, this evaluation give a description of the overarching situation surrounding interactions between foodborne pathogens and human health as well as potential preventative measures.[14] Doriya et al.[15] present a comprehensive view of fermenting fruit drinks without alcohol a focus on enhancing bioactive and nutritional components phenolic substances, nutrients, and elements of this kind, as well as their role in pro/prebiotic diets. Lee et al.[16] discuss the most modern phage and endolysin genetic and protein editing techniques. The

https://doi.org/10.56294/saludcyt2023409

main goal of engineering is to get beyond restrictions including a limited host range, little antibiotic activity, and poor phage and endolysin stability. The development of phage resistance is another goal of phage engineering.In-depth discussion of mixed-species biofilms produced by foodborne pathogens and their increased susceptibility to anti-biofilm removal techniques is highlighted in this paper. A few approaches for managing mixed-species biofilms have also been briefly reviewed, with a particular focus on using bacteriophages in the food business. [17] Probiotics have been proposed as a replacement defensive way of protection against harmful germs in order to enhance food safety and health. In this review, they focus on the probiotics, which their selection criteria, their means of action, and their possibility as alternate biocontrol tools in the food and economic (livestock and aquaculture sectors) fields.

DEVELOPMENT

Mechanisms of Probiotic actions

The creation of antibiotics for the prevention of pathogens' adhesion to the epithelium and mucosa, competition for scarce calories, restriction of pathogens' invasion of the epithelium, immune response modification, and instruction of the structure of the intestinal microbiota are just a few of the ways that probiotics can prevent infection. They can also improve intestinal health, increase the nutritional content of food, and confer advantages for health.Probiotic strains can also display metabolic processes that detoxify inhibitory chemicals and oxygen-scavenging substances like amines or nitrates to establish a favorable anaerobic environment the feeling in the indigenous microbiota. The probiotic strains utilized have a major impact on these metabolic processes and the ability of the gut to survive. Exopolysaccharides that probiotic strains can release can prevent infections from forming biofilms.In figure 1, the Mechanisms of probiotic action are shown.

Figure 1 represents the Mechanisms of probiotic action. a) The elimination of harmful germs through competition. b) The creation of antibacterial agents. c) Struggle for growth hormones and minerals. d) Strengthen intestinal mucosal adhesion. e) Improved epithelial in barrier performance. Enhanced production of IgA (immune stimulus).

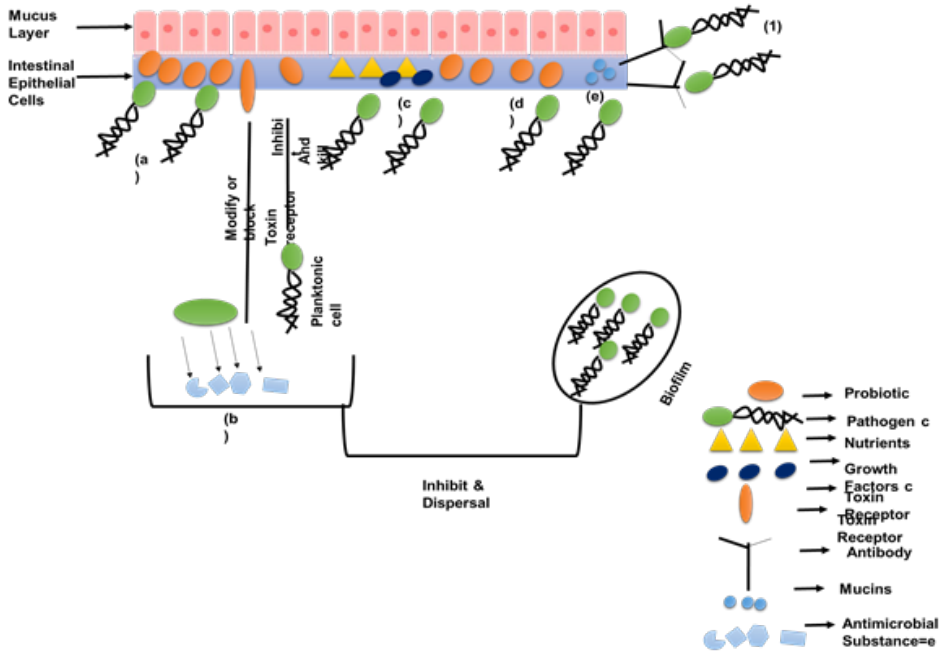

Figure 1. Mechanisms of probiotic action

Biocontrol agents on food and food contact surfaces

A. Vegetables and fresh fruits

Because they contain nutrients that are essential to a person's diet, fresh fruits and vegetables are good for your health. Evidence suggests that these foods have obvious advantages after consumption. Fresh fruits and vegetables are becoming more often consumed, however they could be contaminated or colonized by diseases like Listeria monocytogenes, Salmonella spp., or other organisms. Foodborne outbreaks in a population can be brought on by foods containing such diseases.Lactobacillusrhamnosus GG probiotic was studied for its potential ability to nurture fresh-cut apples against Listeria monocytogenes and Salmonella spp.

B. Fermented foods

One of the most well-liked foods made from fermented milk is cheese, which has been eaten by a large

number of people worldwide. For the isolation of probiotic applicants, cheese can be a valuable source. Shown that Listeria monocytogenes, Streptococcus aureus, a type of Enterococcus faecalis and Escherichia coli were all susceptible to the antibacterial effects of the yeast strains Lactobacillus rhamnosus FS10 and Lactobacillus paracasei PM8, all obtained from cheese. According to the authors, nutritional foods can leverage these possible probiotic varieties to increase food safety.Figure 2 depicts the Inhibition (%).

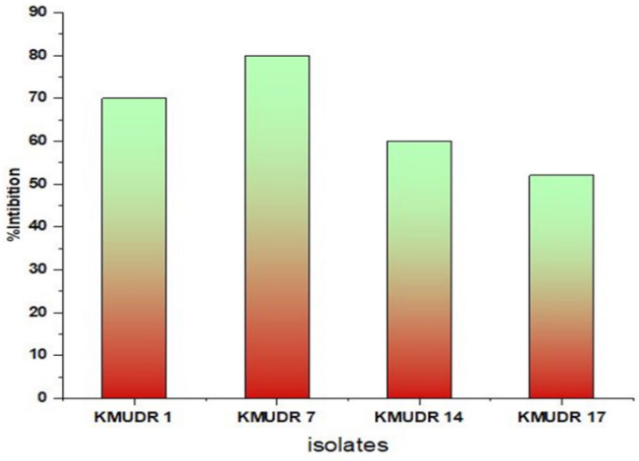

Figure 2. Inhibition (%)

C. Meat products

Since meat and meat products make excellent growth structures for microorganisms, several probiotic strains are used in meat production as starting cultures. Probiotic varieties can prevent the growth of foodborne pathogens in meat products, according to numerous researches.Some probiotic lactic acid bacteria could compete suppress the spread of Listeria monocytogenes pathogens in ready-to-eat (RTE) meat products at refrigeration (5 °C) temperature without affecting the meat's flavor or texture. Salmonella enterica subsp. entericaserovarEnteritidis and Listeria monocytogenes growth were successfully inhibited in 2009 by the application of two strains, lactic acid bacteria ACA-DC179 and the Enterococcus faecium strain PCD71, to raw chicken meat.

D. Food-processing plants and surfaces

A major cause of spoilage of food that results in foodborne illnesses is the production of biofilms by dangerous bacteria on various food processing surfaces and equipment. Probiotic bio films can also be employed as an alternate strategy to lessen the development of pathogenic biofilms in the food sector. These authors discovered that Salmonella enterica subsp. Biofilm formation might be inhibited by LAB probiotic strains from foods utilized in the study. Figure 3 depicts the plants and surface.

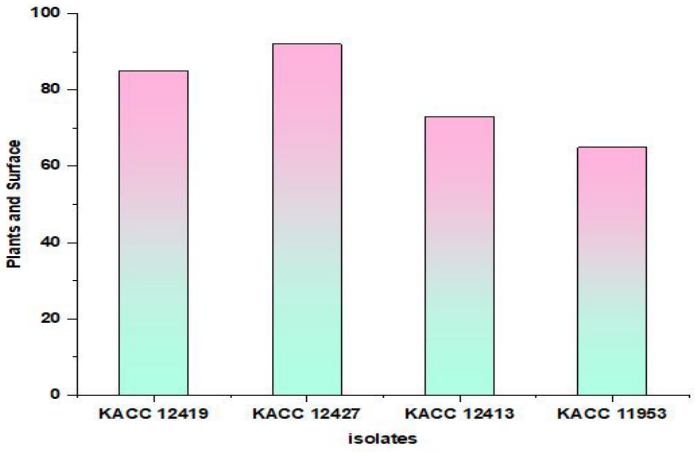

Figure 3. Plants and surface

Role of probiotics in livestock as biocontrol agents

Numerous developing nations rely heavily on different kinds of livestock as a source of both income and food. Zoonotic infections connected to animals can spread to people, posing a severe risk to public health as well

as financial damages to both sectors.According to the European Food Safety Authority (EFSA, 2004b), decrease of pathogens in animals that live is the most efficient way to prevent animal poisoning from foods and spoiling of food. The maintenance and enhancement of animal development and production, as well as the prevention and management of enteric infections, are the two main goals of employing probiotics in animal feeding. By limiting intestinal colonization and spread of prevalent Pathogenic enteric and pathogenic zoonotic organisms, probiotics may therefore be a useful substitute for antibiotic feed additives in controlling the quantity of intestinal pathogens in animals themselves.

A. Poultry

A significant cause of human infection is chicken and poultry products (EFSA, 2015). Numerous investigations have found that Campylobacter spp. are commonly found in poultry. In the EU, campylobacteriosis is a common zoonotic disease linked to animals used for food production (EFSA, 2015). Probiotics have been shown to effectively prevent or reduce the bacterium campylobacter jejuni excretion burden in in vivo experiments, according to a few earlier research. Based on in vitro research that assessed the potential antibacterial bacteria strains' effectiveness against Salmonella infections, isolated probiotic strains have been used in chicken farms. There are a number of probiotics that may be anti-Campylobacter (Table 1). The risk to customers can be successfully decreased by reducing or decreasing the amount of harmful bacteria in contaminated both live and prepared meat from poultry. An effective alternative strategy for decreasing infections in poultry is the administration of probiotics as a biocontrol agent.

Table 1. Anti campylobacter

Probiotic	TargetPathogen	Test	Observedeffect
P93 of Lactobacillus spp.	Jejune Chlamydia	Co-culture and diffusion on an agar plate	(4-6logreduction) &inhibition zone (in vitro)
SBT2055 L.gasseri	Jejune Chlamydia	invivo	1-2logreduction
Types of Bacillus.	Jejune Chlamydia	invivo	1-3logreduction
Both Lb. salivarius MMS122 and MMS151 weigh one pound, and Bacteria salivarius SMXD51	Jejune Chlamydia	(In vitro) Gelatin plate absorption	Inhibitionzone
LB johnsonii BFE663, LB discrete period of time IMT22353, and Lactobacillus fermentum ATCC 931	Jejune Chlamydia	(In vitro) Gelatin plate absorption	Inhibitionzone 0
The species of Bacillus, L. salivarius subspecies salicinius and salivarius, respectively	Jejune Chlamydia	in real time	decrease of 1-3 logs
Paracasei Lb. J.R. + lb. lactis Y + lb. lactisFOa + lb. emphasis placed 15b	Jejune Chlamydia	in real time	decrease of 1-3 logs
Subtilis Bacillus	Salmonellagallinarum	in real time	lowering the pathogenic Pseudomonas pure sample strains.
Bacillussubtilis B2A	Salmonellapopulation	in real time	fewer strains of Salmonella
Lactobacillusjohnsonii F19185	Clostridiumperfringens	in real time	decreased penetration of the species C. perfringens
Lactobacillusjohnsonii	E.coli O78:K80	in real time	less E. coli contamination
Bacillus cereusvar.toyoi	Salmonella entericasubsp. entericaserovarEnteritidis	in real time	decreased colonization with Salmonella Enteritidis (SE)
Enterococcusfaecium	E.coli K88	in real time	less E. coli bacteria
ThreeBacillussubtilis spp.mixture	Jejune Chlamydia	in real time	Log decrease of 1-4

B. Pigs

Probiotic usage in pigs is associated with preventing and treating pathogenic diseases brought on by intestinal imbalance. In a few experiments, supplementation with probiotic cultures was used to effectively manage and

reduce infection by pathogens in pigs (table 2). Noticed four possible probiotic strains, including lactic acid bacteria subspecies.Casei CECT 4043, a type of acidilactici NRRL B-5627, lactis subsp. According to studies conducted by, oral administration of a Lactobacillus fermentum I5007 strain at an intensity of 6 109 CFU/mL daily decreased the number of enteropathogenic Escherichia spp. and Clostridium spp. In neonatal piglets.

C. Cattle

Probiotic supplementation can successfully manage and lower the pathogen burden in the gut of cattle, according to several field investigations (table 2).This is in line with the findings. Who discovered that this type of bacteria and These microbes freudenreichii NP51 (NPC 747), a probiotic combination, were successful in decreasing the fecal discharge of E. Coli O157:H7 in cattle.Another study found that adding acidophilus The lactic acid strain NP51 (NPC 747) to feed efficiently decreased the amount of E. Coli O156:H7 that cattle excreted (by 32 %; NPC 746). According to, who discovered that a probiotic combination of The bacteria known as Pro probiotics and freudenreichiistrain NP51 (NPC 747) was used in this study successful in lowering the fecal dispersion of E. coli O157:H7 in animals.

D. Goat

Probiotic consumption has been proven to be an efficient way to manage and lower the pathogen load in goat guts in a few field studies (table 2). Shigellaand the quantity of Salmonella infection enterobacter in feceswere decreased by 1,20 log and 1,08 log, accordingly, before being tried when goats were given a meal supplement with lactic acid alimentarius DDL 48, the strainThe bacteria bifidobacteriumbifidum DDBA, a strain of Enter DDE 39, and lactic acid bacteria DDL 19 strains of probiotic strains.According to the results of these research, probiotics may have antibacterial defenses from serious pathogenic microbes such Salmonella spp., Escherichia coli, Campylobacter spp., and other intestinal, which could prevent these diseases from colonizing animals. Applying probiotics will thereby increase animal development comparable to eggs, milk, and meat manufacturing and quality.

Table 2. Goat and pig

Animals	Observed Effect	PotentialProbiotic	TargetPathogen
Pig	Decreased Escherichia spp. counts	Enterococcus faecalis, also	Eccherichia coli
	Reduction of Clostridium spp. &The microbe Escher species levels	I5008 fermentation bacteria	The bacteria Escherichia coli and Clostridium species .
	Inhibitory effect against Clostridium perfringens	Enterococcus faecium	Clostridium perfringens
	Reduced fecal shedding of E.coli counts	11180 Enterococcus faecium NCIMB	Escherichia coli
Goat	Reductions of 1,20 log and 1,08 log, correspondingly	The reuteri strain DDL 19 plus lactic acid bacteria alimentarius DDL 48+Bifidobacteriumbifidum DDBA +EnterococcusfaeciumDDE39	Shigella & Salmonella
	Reduction of Clostridium spp. counts	Lactobacillus plantarum PCA236	Species of Clostridium.
Cattle	E. coli O157:H7 feces of excretion should be reduced	Propioni bacterium freudebreichii	E. coli O156:H7
	E. coli fecal secretion has fallen O157:H7 count	Acidophilus Escherichia strain	E. coli O156:H7
	lowering the E. coli O157:H7 numbers that are excreted in feces	lactic acidophilus NP51 and These organisms freudenreichii	E. coli O157:H7

Antibiotics' function as biological controllers in agriculture

In many nations, agribusiness is a major source of income, and within the past 30 years, its sector has seen fast global expansion. The use of antibiotics for managing infections in agriculture may be harmful to the planet and to public health. Although they are more renewable, biotic approaches been extensively used used for disease control in many underdeveloped nations.While additional probiotics commonly used in the industry to name a few, are Aeromonas, Enterobacter, are the fungus P Shewanella, Lactococcus, Leuconostoc, Vibrio,

and the bacteria the fungus Sac species, listed in table 3, the majority of probiotics used as biocontrol agents under consideration in aquaculture belong to the LAB (Lactobacillus and Carnobacterium species) and species of Bacillus.These results do, in fact, suggest that various biotech varieties must be taken into account as biological controls for widespread usage to in agriculture limit disease development.

Table 3. Fungus and species

Conceivable Antibiotic	Variety of Fish	Different Kinds of Fish Affected
Vibrio alginolyticus UTM 102	Litopenaeusvannamei	Protection against Vibrio parahaemolyticus
PI8o streptococci phocae	Monodon Penguin	Inhibitory response to the bacterial exposure
Lactobacillus rhamnosus GG Oreochromisniloticus	Oreochromisniloticus	Defense against the Aeromonas in difficulties of the gut
Pseudomonas sp. MSB1	Oncorhynchusmykiss	flavor bacteria psychrophilum activity suppression in vitro
Pseudomonas sp. M174	Oncorhynchusmykiss	Catfish pathogenic a bacteria called Flapsychrophilum inhibits development
Bacillus sp. C5I18	Oreochromis niloticus	Aeromonas and Pseudomonas species reduction in growth in fish intestinal tissue
Phaeobactergallaeciensis SLV03		
PseudomonasaestumarinaSLV22		
Enterococcus faecium SF68, and Aspergillustoyoi	Aguilar aguilar	reduction of the risk of edwardsiellosisEdwardsiellatarda
Aspergillus broad	Dicentrarchus labrax	The infection prevention by lowering Vibrio bacterium numbers
AspergillusbroadAspergillus broad	Labeorohita	prevention of being infected with the bacterium Aeromonashydrophila
The bacteria Bacillus JB-1 with Aeromonas has sobria GC2	Oncorhynchusmykiss	Protection against Yersinia ruckeri challenge
Bacteria clausii DE5, Bacteria pumilus SE5	Epinepheluscoioides	Reduction of Vibrio levels
GC2 Aeromonas bacteria sobria	Oncorhynchusmykiss	Streptococcosis (caused by Streptococcus iniae) and lactococcosis (produced by Lactococcusgarvieae) controlled
Leuconostocmesenteroides CL CLFP 196, Lactobacillus sakei CLFP 202, and Lactococcuslactis ssp. lactis CLFP 100	Oncorhynchusmykiss	Preservation from the illness furunculosis, which is brought on by the pathogenic agent an Aeromonassalmonicida ssp. salmonicida.

Future research prospects

Probiotics' potential as biocontrol agents is currently a key area of research.As a result, a key factor in the achievement and longevity application of probiotics as agents of biocontrol in meals and agriculture industries is Recognized by customers (brand, marketing, safety, effectiveness, and sensory contest, among other factors). Scientific researchers must persuade customers to accept this by offering accurate, appropriate, and transparent information concerningany health promises. In order to further comprehend molecular processes and decoding the unique gene in probiotics with novel uses, advanced molecular level research is also necessary. We enjoin researchers to concentrate future research on antibiotics due to the gaps in present understanding.

CONCLUSION

In the cattle and seafood areas of farm and the agriculture industry, infectious microbes and the diseases they cause are seen as severe threats to the safety of food. It is difficult to create potential methods of microbial pathogen management that don't have any negative side effects. Numerous strategies have already been developed, however it is seriously worrying how they will impact society. Last but not least, probiotics hold

enormous promise as an alternative and ecologically friendly strategy and seem to be an effective way to manage microbial infections in many regions. The investigations on their actions and potential mechanisms is used to combat infection caused by food are highlighted in this review. The most often employed genera of bacteria in this review as prospective probiotic possibilities are lactic acid, Bacillus, Enterococcus, and lactococcus, which show promising antimicrobials, both in vivo and in vitro activity. Streptococcus aureus, Streptococcus aureus, and Escherichia coli for years without having any negative effects, however when choosing a probiotic, it is important to keep in mind that some of these strains may be more dangerous than others.These genera, including Bacteria and Enterococcus, contain species that have been shown to have harmful effects. In conclusion, research has revealed that probiotics can become a unique strategy to prevent or eliminate foodborne infections and subsequently increase food safety at the stage of customers handle by harnessing its potential antibacterial properties.

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FINANCING

No financing.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

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