ISSN: 2157-2518
Journal of Carcinogenesis & Mutagenesis

OPEN ACCESS Freely available online

Review Article

Probiotics in Cancer Treatment: From the Laboratory to Clinical Practice

Abhinandan Patil*

Department of Pharmaceutics, D.Y. Patil Education Society, (Deemed to be University), Kolhapur, India

ABSTRACT

Probiotics are now being looked at as a possible addition to cancer treatments in both study and clinical settings. This study tries to give an overview of probiotic research as it relates to cancer, with a focus on how it might help avoid cancer, treat it, and improve the health of cancer patients. We look at developmental studies that use cell culture and animal models to look at how well probiotics work in cancer. We focus on how probiotics change the immune system, inflammation, and gut bacteria. The results of clinical studies that looked at probiotics as an add-on therapy for cancer patients are looked at to see how they affected the treatment success, side effects, and quality of life of the patients. We look at the possible benefits of probiotics for certain types of cancer, such as colorectal cancer, breast cancer, and stomach tumors. We also find the best probiotic strains for each type of cancer. We also look at the synergistic benefits of combining probiotics with standard cancer treatments like chemotherapy, radiation therapy, and immunotherapy to improve the effectiveness of treatment and lower side effects. Lastly, we talk about the present problems and future directions of probiotic research for cancer. We focus on personalized methods, ideal doses and treatment plans, finding signs of treatment success, and making probiotic-based therapies. By learning more about how probiotics could be used to treat cancer, we can create personalized, successful, and well-tolerated probiotic treatments to improve cancer outcomes.

Keywords: Gut, Probiotics diseases, Gastro intestinal system

Abbreviations: IFN-γ: Interferon-Gamma; TNF-α: Tumor Necrosis Factor; LI: Like Interleukin; SCFA: Short-Chain Fatty Acids; HDAC: Histone Deacetylase

INTRODUCTION

In recent years, living microorganisms called "probiotics" that might be good for your health have gotten a lot of attention as a hopeful addition to cancer study and treatment. Because of the complicated relationship between the gut bacteria and cancer, people are becoming more interested in how probiotics can affect cancer prevention, treatment, and the general health of cancer patients. In the area of oncology, probiotics are a unique method because they use the power of good bacteria to change different biological processes that are linked to the spread of cancer. Probiotics fight cancer in many ways, including by changing the immune system, reducing inflammation, changing the gut flora, and changing the way the body uses energy. By focusing on these linked pathways, probiotics could improve the effectiveness of treatments, lower the side effects of treatments, and improve the quality of life of patients. But more study is needed to figure out the exact processes and find the best way to use probiotics for different types of cancer and patient groups. In this review, we will look at several important parts of the study on probiotics and cancer. We will look into developmental studies that use cell culture and animal models to find out how well probiotics prevent and treat cancer. We will also look at how probiotics affect the growth and progression of cancer at the molecular level, focusing on their power to change the immune system, inflammation, and gut microbiota. Also, we will talk about the results of clinical studies that look at the use of probiotics as an extra medicine for cancer patients, including

Correspondence to: Abhinandan Patil, Department of Department of Pharmaceutics, D.Y. Patil Education Society, (Deemed to be University), Kolhapur, India, E-mail: abhisirdyp@gmail.com

Received: 19-Jul-2023, Manuscript No. JCM-23-22257; **Editor assigned:** 21-Jul-2022, Pre QC No. JCM-23-22257; **Reviewed:** 02-Aug-2023, QC No. JCM-23-22257; **Revised:** 09-Aug-2023, Manuscript No. JCM-23-22257; **Published:** 18-Aug-2023, DOI: 10.35248/2157-2518.2.14.425.

Citation: Patil A (2023) Probiotics in Cancer Treatment: From the Laboratory to Clinical Practice. J Carcinog Mutagen. 14:425.

how they affect the results of treatment, side effects, and the quality of life of the patients. We will also talk about the possible benefits of probiotics for certain kinds of cancer, like colorectal cancer, breast cancer, and gut tumors, with the goal of finding the best probiotic strains for each kind of cancer. We will also look into the synergistic benefits of combining probiotics with standard cancer treatments like chemotherapy, radiation therapy, and immunotherapy to improve the effectiveness of treatment and lower side effects. Lastly, we will talk about the current difficulties and future directions of probiotic research for cancer. These include personalized methods, ideal doses and treatment plans, finding biomarkers for how well a treatment is working, and making probiotic-based medicines [1-4].

A hopeful way to improve cancer outcomes is to figure out what role probiotics play in cancer and use them to help current treatments work better. By learning more about how probiotics, the host, and the surroundings of the tumor work together, we can make it easier to use personalized, effective, and well-tolerated probiotic interventions to fight cancer.

LITERATURE REVIEW

Preclinical studies

Preclinical studies are a key part of figuring out if a possible therapy, like probiotics, will work and be safe to use in preventing and treating cancer. These studies, which were mostly done with cell cultures and animal models, tell us a lot about how probiotics work and what effects they might have for people with cancer. When studying cell culture, scientists use cancer cell lines that have been grown in a lab. Researchers can use these studies to look at the direct effects of probiotics on cancer cells. They can look at things like cell growth, cell death (apoptosis), cell cycle control, and the expression of genes and proteins linked to the development of cancer. By putting cancer cells in contact with different types and amounts of probiotics, researchers can test their possible anticancer effects and figure out the best way to treat cancer [5-11].

Animal models, like mice, rats, and other animals, are used to show how bacteria, the host, and the tumor microenvironment interact with each other. These models make it possible to figure out how probiotics affect the growth of tumors, how they spread, and how long people live in general. Animal studies also give us a chance to look at the effects of probiotics on the whole body, like how they affect immune reactions, inflammation, and the gut flora. Researchers can give probiotics by mouth or in other ways and look at how they affect the growth of tumors and any possible side effects or harm. Studies that didn't involve people have shown that probiotics might be useful in preventing and treating cancer. In cell culture and animal models, they have shown that certain probiotic strains can stop the growth of tumor cells, cause apoptosis, change immune reactions, and decrease inflammation. These results are a good starting point for more research and will help guide the design of clinical studies to test these effects on people.

But it's important to keep in mind that preliminary studies have some problems. The complexity of the tumor microenvironment, immune reactions, and relationships with other cells and organs in the body may not be fully captured by cell culture studies. Even though animal models are more like how humans work, they may not always properly reflect human reactions or predict what will happen in a clinical setting. So, putting preclinical results to use in the real world needs careful thought and confirmation through well-designed clinical studies.

In conclusion, cell culture and animal models used in basic studies have been very helpful in figuring out how probiotics might help avoid and treat cancer. These studies have given us important information about how things work and have helped shape clinical trials. But more research is needed to confirm the results of animal studies and figure out the best probiotic types, doses, and treatment plans for people.

Understanding probiotics at the molecular level

Probiotics have gotten a lot of attention because they might help avoid and treat cancer. Understanding how probiotics fight cancer at the molecular level is important if you want to use them in clinical settings in the best way possible. Several ways have been found, such as adjusting the immune system, causing inflammation, and changing the gut flora. The immune system is one of the most important ways that probiotics affect the growth and spread of cancer. Probiotics can connect with immunity cells like macrophages, dendritic cells, and natural killer cells to make them work better and help the immune system fight tumors. They can increase the release of cytokines that kill cancer cells, such as Interferon-Gamma (IFN-γ) and Tumor Necrosis Factor-alpha (TNF-α). Probiotics can also help keep the balance between pro-inflammatory and anti-inflammatory immune reactions. This helps keep immune homeostasis and prevents chronic inflammation, which can lead to cancer. Cancer is often caused by inflammation, and research has shown that probiotics can reduce inflammation. They can stop the release of cytokines that cause inflammation, Like Interleukin-6 (IL-6) and Interleukin-1 beta (IL-1), and make more anti-inflammatory cytokines, Like Interleukin-10 (IL-10), come out. By changing the way, the body responds to inflammation, probiotics make it harder for tumors to grow and spread [5-11].

The complex population of microorganisms that live in the GI system, called the gut microbiota, is a key factor in health and disease, including cancer. Probiotics can change how the gut flora is made up and what it does. They can help good bacteria grow and stop bad bacteria from growing. This change in the gut bacteria can affect the growth of cancer in different ways. Metabolites, like Short-Chain Fatty Acids (SCFAs), can be made by probiotics. These SCFAs have been shown to fight cancer. SCFAs can stop cancer cells from growing, trigger death, and control how the cell cycle goes. Probiotics can also improve the gut barrier, which makes it less likely that dangerous substances and toxins will move from the gut into the bloodstream. This can lead to inflammation and the growth of cancer. Also, probiotics can change the digestion of food components like fiber and antioxidants by interacting with them. This can lead to

the production of beneficial molecules that may help fight cancer. For example, bacteria can turn food fiber into butyrate, which has been shown to stop the growth of tumors by stopping the action of Histone Deacetylase (HDAC) enzymes. Overall, probiotics fight cancer through a number of different but linked ways. Probiotics make it harder for tumors to grow and spread by changing the way the immune system works, cutting inflammation, and changing the gut flora. But it's important to keep in mind that the exact processes and effects can change based on the probiotic strains and other factors. More study is needed to fully understand the complex molecular processes involved and to find the best probiotic strains and treatment plans for each type of cancer.

Clinical Trials: Adding probiotics to other treatments

Clinical studies are the best way to find out if a treatment, like probiotics, is safe and effective as an add-on medicine for cancer patients. These studies give us important information about how probiotics affect the results of treatment, any possible side effects, and the quality of life of patients.

Using probiotics with normal cancer treatments like chemotherapy, radiation therapy, and surgery has been looked at in a number of clinical studies. The goal of these studies is to find out how probiotics affect how well treatments work, including how well tumors respond, how long people live without their cancer getting worse, and how long people live generally. The results of these trials have been potential, and some studies show that probiotics may help cancer patients respond better to medication, feel less sick from treatment, and have better outcomes overall. In clinical studies, people with cancer are also tested to see how safe and well they can handle probiotics. In general, probiotics are thought to be safe, but different types and forms may have different side effects. Clinical studies carefully track and measure the number and intensity of side effects that can happen when probiotics are used. Mild digestive problems like bloating, flatulence, and diarrhea are often mentioned as side effects of probiotics. But major side effects are rare, and most cancer patients are able to handle probiotics well [11-19].

In clinical studies, the quality of life of the patient is an important thing to look at. Cancer medicines often have big effects on a patient's health, like making them tired, giving them stomach problems, or making their immune system less effective. Researchers have looked into how probiotics might help ease the side effects of medicine and improve the quality of life for patients. Clinical studies look at many aspects of quality of life, such as the seriousness of symptoms, how well the body works, how well the mind is doing, and how satisfied the person is overall. Some studies have shown that probiotics can help cancer patients feel better generally and have fewer side effects from their treatments. It's important to remember that the results of clinical studies that looked at probiotics in cancer patients were not all the same. Different results can be caused by changes in how the study was set up, the probiotic strains and doses used, the type of cancer, and the patient group. So, more study is of of treatment for different types of cancer and different groups of patients [19-22].

In conclusion, clinical studies that look at probiotics as an add-on therapy for cancer patients give us important information about how they affect treatment results, side effects, and the quality of life of cancer patients. Even though the results look hopeful, more well-designed clinical studies are needed to find out how best to use probiotics for different types of cancer, treatment plans, and patient groups. Probiotics might help cancer patients respond better to treatment, feel better generally, and have fewer side effects from medication.

Benefits of bacteria for certain types of cancer

Researchers have looked into how probiotics might help with different kinds of cancer, with a focus on colorectal cancer, breast cancer, and stomach cancers. Understanding how probiotics might affect different kinds of cancer is important for tailoring treatments and getting the best results. Colorectal cancer is one of the types of cancer that has been studied the most when it comes to probiotics. Clinical trials and preclinical studies have shown that probiotics may be able to lower the chance of developing colon cancer and improve the effectiveness of treatment. Some types, like *Lactobacillus acidophilus*, *Bifidobacterium bifidum*, and *Lactobacillus casei*, have been shown to be able to change the makeup of the gut microbiota, stop cancer cells from growing, and lower inflammation in the colon. These benefits may help avoid and treat colorectal cancer in some way. But more study needs to be done to figure out the best probiotic strains, doses, and treatment plans for this type of cancer. The study of probiotics is also interested in breast cancer. Studies have looked into the possible benefits of probiotics for lowering the risk of breast cancer and easing the side effects of treatment. Probiotics may change the way estrogen is used in the body, control immune reactions, and improve the function of the gut barrier. All of these things may affect the growth and progression of breast cancer. Some probiotic strains that have shown potential in breast cancer studies are *Lactobacillus rhamnosus*, *Lactobacillus plantarum*, and *Bifidobacterium lactis*. But more clinical studies are needed to find out how well they work and which types are best for preventing and treating breast cancer [21-28].

Gastrointestinal tumors include a wide range of cancers that affect the digestive system, such as stomach, esophagus, and pancreatic cancers. Probiotics have been looked at to see if they could lower the chance of these cancers and make treatment work better. Some probiotic types, like *Lactobacillus rhamnosus* GG and *Saccharomyces boulardii*, have been shown to reduce inflammation, change the gut bacteria, and boost the immune response. These effects may help avoid and treat gastrointestinal cancers. But more research needs to be done to find out how probiotics affect each type of cancer in this group. It's important to remember that the best probiotic strains and ways to treat cancer can change based on the type of cancer, its state, and the patient's own traits. When choosing probiotics, you should think about how they work, how they might mix with other medicines, and what side effects they

might have. Also, personalized methods, such as microbiome analysis, could help find the best probiotic types for each patient [21-25].

In conclusion, there is more and more study into the possible benefits of probiotics for certain types of cancer, such as colorectal cancer, breast cancer, and gastrointestinal tumors. Researchers have found that probiotics may help avoid or treat these cancers by changing the gut flora, immune responses, and inflammation. But more well-designed clinical studies are needed to find out which bacteria strains, doses, and treatment plans work best for each type of cancer. More study in this area could lead to personalized ways to avoid and treat cancer that are based on probiotics.

Combination therapies: Probiotics and traditional cancer medicines work better together

Combining probiotics with traditional treatments for cancer has become a topic of interest in cancer study. The idea behind these combination therapies is to use the possible synergistic effects of probiotics and traditional treatments to improve the effectiveness of treatments and lessen the side effects of treatments. Chemotherapy, radiation therapy, and immunotherapy are all popular ways of treating cancer. But these treatments can have serious side effects and may change the balance of the gut bacteria, which is an important part of keeping the body healthy as a whole. Probiotics may be able to change the gut flora, boost immune responses, and lessen the bad effects of these medicines. Several studies have looked at what happens when probiotics and chemotherapy are used together. Probiotics may help lessen the side effects of treatment on the gut, like diarrhea and mucositis. They can also make chemotherapy work better by changing how drugs are used, making it easier for drugs to get to the tumor, and making cancer cells more sensitive to treatment. For example, in models of colorectal cancer and breast cancer, it has been shown that certain types of probiotics make treatment drugs work better. Radiation therapy is another type of medicine that can be helped by taking probiotics at the same time. Radiation treatment can hurt the intestinal lining and change the bacteria that live in the gut. Probiotics may help keep the health of the gut barrier, lower inflammation caused by radiation, and speed up tissue repair. Studies have shown that probiotics can help cancer patients with diarrhea caused by radiation treatment and improve their quality of life. Immunotherapy, which tries to make the immune system better at finding and killing cancer cells, has had a lot of success with some types of cancer. Probiotics might make immunotherapy work better by changing how the immune system responds and making the environment inside the tumor better. Preclinical studies have shown that certain probiotic types can make immune checkpoint inhibitors and cancer vaccines work better against tumors, leading to better treatment results. Importantly, choosing the right probiotic types, when to take them, and how much to take are all important parts of getting the best results from combination treatments. Probiotics should be carefully chosen to work with the usual medicine and the needs of each patient. Also, it's important to think about how probiotics and medicines used in traditional cancer treatments might combine with each other to avoid side effects or problems with how well the treatment works. Even though mixing probiotics with traditional cancer treatments could be helpful, more clinical studies are needed to prove their effectiveness and figure out the best treatment plans. These studies should focus on certain types of cancer, treatment plans, and groups of patients. To keep patients safe and make sure the treatment works, it will also be important to keep a close eye on the results and side effects of the treatment [21-31].

In conclusion, studying the synergistic effects of mixing probiotics with traditional cancer medicines is an exciting way to improve the effectiveness of treatment and lessen side effects. Probiotics may be able to change the gut flora, improve immune reactions, and lessen the harmful effects of treatments. But more study, including well-designed clinical studies, is needed to find the best probiotic strains, treatment plans, and patient selection factors for effective combination therapies in cancer care.

Goals for the future

Cancer study on probiotics is an evolving area that offers exciting chances to improve ways to avoid and treat cancer. But there are a few problems and goals for the future that need to be solved before probiotics can be used to their full potential in cancer treatment. In probiotic study, the growth of personalized approaches is a very important part. The gut microbiota of each person is different, as is how they react to probiotics. This is because of things like genetics, food, habits, and underlying health issues. Personalized methods that look at the microbiota makeup of each person could help find the best probiotic types, doses, and treatment plans for each person. Using technologies like metagenomics and metabolomics can tell us a lot about how a person's gut microbiome is made up and help us design personalized probiotic treatments. Another important area of research is figuring out the best doses and treatment plans for bacteria. Probiotics can have different affects depending on how much you take, so finding the right mix is important to get the therapeutic results you want. Also, the length of probiotic treatment and when it should be given in connection to standard cancer treatments need to be carefully studied to make sure they work as well as possible. Finding signs that show how well a treatment is working is a big problem in cancer probiotic research. Biomarkers could help predict which patients are most likely to benefit from probiotic therapy and track how well treatments are working. Molecular markers in the gut bacteria, the immune system of the host, and the microenvironment of the tumor could be good predictors of how well a treatment is working and help choose probiotics for specific interventions [28-37].

Using probiotics to make medicines is an exciting new area of study in the field of cancer. Probiotics can be engineered or changed to make them more effective at fighting cancer and to help them get to specific tumor spots. Synthetic biology and genetic engineering methods that are getting better can make it easier to make probiotics with specific functions, like making anticancer metabolites or expressing beneficial molecules. Also, putting probiotics into new ways of delivering them, like nanoparticles or hydrogels, could make them more stable and effective. Also, full clinical studies are needed to find out if

probiotics are safe, effective, and have long-term effects on preventing and treating cancer. For probiotic-based treatments in oncology to be approved by regulators, they must be based on large, well-designed studies with a wide range of patient groups.

In the end, there are many ideas for the future of probiotic studies for cancer. Key areas that need more research are personalized approaches, the best dosages and treatment plans, the finding of biomarkers, and the creation of probiotic-based therapies. By solving these problems and learning more about how probiotics work in cancer, we can use them to their fullest potential and help cancer patients have better results.

CONCLUSION

Cancer study on probiotics has a lot of potential to improve how cancer is treated, how it is prevented, and how patients do after getting cancer. Evidence from animal studies, clinical trials, and ongoing research shows that probiotics may be able to change some biological processes that are linked to the growth and spread of cancer. By focusing on the immune system, inflammation, and the bacteria in the gut, probiotics offer a diverse way to improve the effectiveness of treatments, lessen the side effects of treatments, and improve the quality of life of patients. In cell culture and animal models, probiotics have been shown to be effective at stopping tumor growth, boosting apoptosis, and adjusting immune reactions. Clinical studies that looked at the use of probiotics as an add-on medicine for cancer patients showed that the treatments worked better and the patients felt better. But more study is needed to find the best probiotic strains, doses, and treatment plans for different types of cancer and patient groups. Some types of cancer, like colon cancer, breast cancer, and gastrointestinal tumors, have been studied to see if probiotics could help. Evidence shows that certain probiotic strains may help avoid and treat these cancers, but more research is needed to figure out how well they work and how they work. Also, the synergistic benefits of combining probiotics with traditional cancer treatments like chemotherapy, radiation therapy, and immunotherapy have shown promise in improving treatment effectiveness and lowering side effects.

As study on probiotics moves forward, future directions include personalized methods, ideal dosages and treatment plans, finding biomarkers for treatment success, and making probiotic-based medicines. Taking into account how a person's gut microbiome is made up can help tailor probiotic therapy, and finding biomarkers can help decide which treatments to use. Also, improvements in genetic engineering and transportation methods make it possible to make probiotics that fight cancer even better. In conclusion, probiotics are a potential way to study cancer and treat it in the field. Probiotics can be used to improve the results of cancer patients by taking advantage of their ability to change immune reactions, inflammation, and the microbiota in the gut. But more study, like large-scale clinical studies and personalized methods, is needed to find the best probiotic interventions and use them to their full potential in cancer care. With more research and development, probiotics could change the way cancer is treated and help patients live longer, healthier lives.

REFERENCES

1. Afzal M, Mazhar SF, Sana S, Naeem M, Rasool MH, Saqalein M, et al. Neurological and cognitive significance of probiotics: A holy grail deciding individual personality. Future Microbiol. 2020; 15(11):1059-1074.
2. Markowiak P, Śliżewska K. Effects of probiotics, prebiotics, and synbiotics on human health. Nutrients. 2017; 9(9):1021.
3. Kazemian N, Mahmoudi M, Halperin F, Wu JC, Pakpour S. Gut microbiota and cardiovascular disease: Opportunities and challenges. Microbiome. 2020; 8(1):1-7.
4. Hills RD, Pontefract BA, Mishcon HR, Black CA, Sutton SC, Theberge CR. Gut microbiome: Profound implications for diet and disease. Nutrients. 2019; 11(7):1613.
5. Panebianco C, Andriulli A, Pazienza V. Pharmacomicrobiomics: Exploiting the drug-microbiota interactions in anticancer therapies. Microbiome. 2018; 6(1):1-3.
6. Khan AA, Shrivastava A, Khurshid M. Normal to cancer microbiome transformation and its implication in cancer diagnosis. Biochim Biophys Acta. 2012; 1826(2):331-337.
7. Khan AA, Nema V, Khan Z. Current status of probiotics for prevention and management of gastrointestinal cancers. Expert Opin Biol Ther. 2021; 21(3):413-422.
8. Khan AA, Khurshid M, Khan S, Alshamsan A. Gut microbiota and probiotics: Current status and their role in cancer therapeutics. Drug Dev Res. 2013; 74(6):365-375.
9. Sedighi M, Zahedi BA, Hamblin MR, Ohadi E, Asadi A, Halajzadeh M, et al. Therapeutic bacteria to combat cancer; current advances, challenges, and opportunities. Cancer Med. 2019; 8(6): 3167-3181.
10. Zur Hausen H. The search for infectious causes of human cancers: Where and why. Virology. 2009; 392(1):1-10.
11. Ishaq S, Nunn L. *Helicobacter pylori* and gastric cancer: A state of the art review. Gastroenterol Hepatol Bed Bench. 2015; 8(l1):S6.
12. Khan AA, A Abuderman A, Ashraf MT, Khan Z. Protein–protein interactions of HPV–*Chlamydia trachomatis*–human and their potential in cervical cancer. Future Microbiol. 2020; 15(7):509-520.
13. Khan AA, Khan Z, Malik A, Kalam MA, Cash P, Ashraf MT, et al. Colorectal cancer-inlammatory bowel disease nexus and felony of *Escherichia coli*. Life sciences. 2017; 180:60-67.
14. Khan AA, Khan Z, Malik A, Shrivastava A, Jain SK, Alshamsan A. Computational prediction of *Escherichia coli* proteins host subcellular targeting and their implications in colorectal cancer etiology. Cancer Lett. 2015; 364(1):25-32.
15. Khan AA. *In silico* prediction of *Escherichia coli* proteins targeting the host cell nucleus, with special reference to their role in colon cancer etiology. Journal of Computational Biology. 2014; 21(6):466-475.
16. Khan AA, Cash P. *E. coli* and colon cancer: Is mutY a culprit?. Cancer Lett. 2013; 341(2):127-131.
17. Tewari M, Mishra RR, Shukla HS. *Salmonella typhi* and gallbladder cancer: Report from an endemic region. Hepatobiliary Pancreat Dis Int. 2010; 9(5):524-530.
18. Sheflin AM, Whitney AK, Weir TL. Cancer-promoting effects of microbial dysbiosis. Curr Oncol Rep. 2014; 16:1-9.
19. Jenkins SV, Robeson MS, Griffin RJ, Quick CM, Siegel ER, Cannon MJ, et al. Gastrointestinal tract dysbiosis enhances distal tumor progression through suppression of leukocyte trafficking. Cancer Res. 2019; 79(23):5999-6009.
20. Gao Z, Guo B, Gao R, Zhu Q, Qin H. Microbiota disbiosis is associated with colorectal cancer. Front Microbiol. 2015; 6:20.
21. Xuan C, Shamonki JM, Chung A, DiNome ML, Chung M, Sieling PA, et al. Microbial dysbiosis is associated with human breast cancer. PLoS One. 2014; 9(1):e83744.

22. Malla MA, Dubey A, Kumar A, Patil A, Ahmad S, Kothari R, et al. Optimization and elucidation of organophosphorus and pyrethroid degradation pathways by a novel bacterial consortium C3 using RSM and GC-MS-based metabolomics. J Taiwan Inst Chem Eng. 2023; 144:104744.
23. Munot N, Kandekar U, Rikame C, Patil A, Sengupta P, Urooj S, et al. Improved mucoadhesion, permeation and *in vitro* anticancer potential of synthesized thiolated acacia and karaya gum combination: A systematic study. Molecules. 2022; 27(20):6829.
24. Munot N, Kandekar U, Giram PS, Khot K, Patil A, Cavalu S. A comparative study of quercetin-loaded nanocochleates and liposomes: Formulation, characterization, assessment of degradation and *in vitro* anticancer potential. Pharmaceutics. 2022; 14(8):1601.
25. Manikyam HK, Tripathi P, Patil SB, Lamichhane J, Chaitanya M, Patil AR. Extraction, purification, and quantification of hesperidin from the immature Citrus grandis/maxima fruit Nepal cultivar. Asian J Nat Prod Biochem. 2022; 20(1).
26. Patil A, Munot N, Patwekar M, Patwekar F, Ahmad I, Alraey Y, et al. Encapsulation of lactic acid bacteria by lyophilisation with its effects on viability and adhesion properties. Evid Based Complement Alternat Med. 2022; 2022.
27. Nalawade AS, Gurav RV, Patil AR, Patwekar M, Patwekar F. A comprehensive review on morphological, genetic and phytochemical diversity, breeding and bioprospecting studies of genus *Chlorophytum* Ker Gawl. from India. Trends Phytochem Res. 2022; 6(1):19-45.
28. Patil A, Balkundhi S, Joshi H, Ghewade G, Gurakesh K. Mehsana buffalo milk as prebiotics for growth of lactobacillus. Int J Pharm Pharm Res. 2011; 114-117.
29. Das N, Ray N, Patil AR, Saini SS, Waghmode B, Ghosh C, et al. Inhibitory effect of selected Indian honey on colon cancer cell growth by inducing apoptosis and targeting the β-catenin/Wnt pathway. Food Funct. 2022; 13(15):8283-8303.
30. Patil MJ, Mali V, Mali A. The diverse cytotoxicity evaluation of lactobacillus discovered from sheep milk. Acta Sci Pharm Sci. 2021; 5(12):69-70.
31. Patil A, Disouza J, Pawar S. Probiotic potential of *Lactobacillus plantarum* with the cell adhesion properties. J Glob Pharma Technol. 2018; 10(12).
32. Patil A, Pawar S, Disouza J. Granules of unistrain lactobacillus as nutraceutical antioxidant agent. Int J Pharm Sci. 2018; 9(4): 1594-1599.
33. Patil A, Mali V, Patil R. Banana fibers camouflaging as a gut worm in a 6-month-old infant. Iberoam J Med. 2020; 2(3):245-247.
34. Munot NM, Shinde YD, Shah P, Patil A, Patil SB, Bhinge SD. Formulation and evaluation of chitosan-plga biocomposite scaffolds incorporated with quercetin liposomes made by qbd approach for improved healing of oral lesions. AAPS PharmSciTech. 2023; 24(6): 147.
35. Patil A. Psychology in the age of technology dependence and the mobile dilemma. 2023.
36. Patil A, Kotekar D, Chavan G. knowing the mechanisms: How probiotics affect the development and progression of cancer. 2023.
37. Pawar V, Patil A, Tamboli F, Gaikwad D, Mali D, Shinde A. harnessing the power of AI in pharmacokinetics and pharmacodynamics: A comprehensive review. AAPS PharmSciTech. 2021; 14(2):426-439.