Turkish Journal of Agriculture - Food Science and Technology, 13(s2): 3503-3507, 2025
DOI: https://doi.org/10.24925/turjaf.v13is2.3503-3507.8050

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Investigation of the Possibility of Using Parabiotic Metabolites as Media/Prebiotics by *Streptoccus thermophilus* and Probiotic *Lactiplantibacillus plantarum* Bacteria

Abdullah Demirci[1, *]

[1]*Bingöl University Graduate School of Natural and Applied Sciences Department of Bee and Bee Products, 12000, Bingöl, Türkiye*
[*]*Corresponding author*

ARTICLE INFO

Research Article

Received : 02.07.2025
Accepted : 13.09.2025

Keywords:
Lactiplantibacillus plamtarum
Non-Living Bacterial Cells
Parabiotic Metabolites
Prebiotic
Streptococcus thermophiles

ABSTRACT

Microorganisms need suitable conditions (temperature, pH and environment) specific to each microorganism in order to survive. It is also known that different microorganisms in the same environment compete for life with each other. In terms of health benefits, it is generally desired that probiotic bacteria maintain their viability for a longer period of time. For this purpose, prebiotics (inulin, trihalose, skim milk powder, whey protein isolate (WPI), ectoin, etc.) or inactive bacterial cells (parabiotics) are added to the medium of probiotic bacteria to maintain the viability of microorganisms. In this study, we investigated whether non-viable bacterial cells can be used as medium or prebiotic by *Streptococcus thermophilus* ATCC 14485 and probiotic *Lactiplantibacillus plantarum* 5102 bacteria. In our study, 2.5% WPI was used as a positive control. *S. thermophilus* and *Burckholderia* sp. bacteria are parabiotic and their prebiotic usability by *S. thermophilus* and probiotic *L. plantarum* bacteria was tested. As a result, *S. thermophilus* was able to utilize both its own and *Burckholderia* sp. non-viable cells as a prebiotic, while *L. plantarum* was only partially able to utilize *S. thermophilus* non-viable cells as a prebiotic.

[a]*ademirci@bingol.edu.tr* *https://orcid.org/0000-0002-0422-5632*

This work is licensed under Creative Commons Attribution 4.0 International License

Introduction

Probiotics are microorganisms known to be beneficial in protecting human health (Hill et al. 2014). Therefore, people prefer probiotic-rich foods (fermented foods). However, probiotic bacteria are damaged during processes such as food processing, transportation and storage. On the other hand, probiotic bacteria taken with food must successfully pass through the gastrointestinal tract and be cloned in the intestines (Dicks and Botes, 2010; Kathiriya et al., 2023). For these reasons, various methods such as encapsulation, freeze-drying, lyophilization, and addition of prebiotics have been tried to preserve the viability of probiotics (Harel and Tang, 2023; Orhan et al., 2024).

Prebiotics can be added to fermented milk products, encapsulated with probiotic bacteria or used directly (Demirci, 2024; Demirci et al., 2025). Galactooligosaccharides, gannanoligosaccharides, lactulose, inulin, fructans, skim milk powder, sucrose, trihalose, ectoine, whey proteins etc. are used as prebiotics (Ferreira et al., 2023; Verma et al., 2023; Kumari et al., 2024).

In the study by Skrlec et al. (2019), trihalose and sucrose were used as prebiotics to keep probiotic *L. plantarum* ATCC, 8014 bacteria alive for a longer period of time. In the application, prebiotic products were mixed with polyethylene oxide and electrospun.

In the study conducted by Peredo et al. (2016), as natural prebiotics, potato starch, carnivorous extract and inulin were used to form the encapsulation material together with alginate. The encapsulated bacteria (*L. casei* Shirota, *L. plantarum* LP17 and LP33) maintained cell viability longer during gastric and intestinal simulation tests.

In a study conducted by the authors Demirci et al. (2024), *S. hermophilus* and probiotic *L. bulgaricus* bacteria were electrospinned with WPI and salep glucomannan to produce yogurt with nanotube-shaped (protein-based) capsules. The encapsulation was reported to improve the physicochemical properties of yogurt while maintaining bacterial viability longer than the control sample.

Paraprobiotics are components of non-living microorganisms and reported to provide various potential benefits such as modulating the immune system, exerting anti-inflammatory effects and strengthening the intestinal barrier (Nataraj et al., 2020; Thakur and Kaur 2025).

They are also used in areas such as food supplements, functional foods, cosmetics and feed industry (Franco 2024; Hosseini et al., 2024).

The non-living cells of *L. acidophilus* ATCCSD 5221 and *Bifidobacterium* (*B.) lactis* BB-12 bacteria were used to produce yogurt as paraprobiotics (inactive probiotic

bacteria). Commercial yogurt starters were also used in the application. The water holding capacity and viscosity of the yogurt produced with the addition of paraprobiotics increased while syneresis decreased. This was thought to be due to the utilization of peptides and amino acids released from non-living cells by the yogurt starter culture bacterial (Parvarei et al., 2021).

It is stated that paraprobiotics can be consumed as safe substances that can strengthen the immune systems or elderly individuals. Paraprobiotics provides anti-inflammatory, antiproliferative and antioxidant health benefits to the consumer and may have antagonistic effects against pathogens (Siciliano et al., 2021).

As seen in these studies, new prebiotics or media are needed to maintain the viability of beneficial bacteria for longer periods of time. In this study, we aimed to evaluate the usability of parabiotic, non-living bacterial cells as prebiotics or media. In this study, non-living cells of *S. hermophilus* and *B.* sp. bacteria were examined for their ability to be a medium or prebiotic for *S. thermophilus* and probiotic *L. plantarum* bacteria.

Materials and Methods

Materials

Among the bacterial isolates used in the study, *S. thermophilus* ATCC 14485 and *L. plantarum* 5102 were obtained from the Department of Food Engineering (Atatürk University, Erzurum, Türkiye), while *Burkholderia* sp. was isolated from wastewater (Orhan et al., 2021). The chemicals used during the test were of analytical purity and were obtained from Merck/Sigma Aldrich A.Ş.

Obtaining Non-Living Bacterial Cells (Parabiotics)

To obtain non-living bacterial cells, *S. thermophilus* was inoculated in M17 medium and *Burkholderia* sp was inoculated in MRS medium and incubated at 37.5°C for 24h. The cultures were passaged for the second time in the same medium by adjusting the density (OD_{600}=0.0-0.1). After 72h of incubation, the cultures were harvested and inactivated. For inactivation, they were centrifuged at 5000 rpm for 5 minutes (Electromag Centrifuge M2815PR) and washed twice with purified water. Afterwards, the cells were lysed by ultrasonication (Protech KDM-103, Ultrasonicator) at 40°C and autoclaved (Nastechnik NST-24L, autoclave) at 121°C for 15 minutes for sterilization (Parvarei et al., 2021; Caroline Almada et al., 2021; Almada Erix et al., 2021).

Development of Test Bacterial and Setting up The Experiment

Streptoccus thermophilus ATCC 14485 and *Burkholderia* sp. were used as test bacteria. *S. thermophilus* ATCC 14485 was grown in M17 broth medium and *B.* sp. was grown in MRS broth medium. The density of fresh cultures was adjusted for the application. In the application; the media suitable for each bacterium were used as negative control. For the positive control, WPI, (90g protein/100g) was prepared at 5% concentration half and half with the medium and the final concentration was 2.5% WPI. Inactivated cells were also added in the same ratio as half and half medium. All treatment tubes were inoculated with 0.5% test bacteria. At different times (0-6-12-18-36-48h and 72h) of incubation at 37.5°C, spectrophotometric measurements were taken. At the time of incubation when bacterial growth was thought to be the best, the petri method was used for counting and verification (Demirci et al., 2024).

Probiotic Bacteria Count

S. thermophilus ATCC 14485 and *L. plantarum* 5102 probiotic bacteria were enumerated. 1 ml sample was taken and dilutions up to 10^5-10^{10} CFU/ml were prepared with 9 ml sterile physiological water and cultures were made on appropriate media. M17 agar was used for *S. thermophilus* and MRS agar (anaerobic medium) for *L. plantarum*. After 48h incubation at 37.5°C, colonies between 30-300 were counted and evaluated. The same samples were run in three parallel. All results are presented in log CFU/ml (Da Silva et al., 2017; Xu et al., 2020; Orhan et al., 2021).

Statistical Analysis

Statistical analysis was performed using one-way ANOVA using SPSS for Microsoft Windows (version 22.0). Results are presented as means and standard deviations (SD) of three experiments

Results and Discussion

Probiotic bacteria in the large intestine form an important part of the human immune system. (Hill et al. 2014). Different techniques (coating, lyophilization or freeze-drying) are used to preserve both the probiotics in our body and the probiotics we get through fermented foods. Consumption of fermented foods with high probiotic and prebiotic content is preferred for health (Toylar et al., 2020; Cattellone et al., 2021). Recently, with the development of technology, micro/nano encapsulation methods have been used to increase the viability of probiotic bacteria (Demirci et al., 2025). While probiotic bacteria are encapsulated in the studies, prebiotics can also be encapsulated on the other side. Encapsulated prebiotics pass through the gastrointestinal tract and support probiotic bacteria in the intestinal environment, allowing them to maintain their viability longer (Demirci et al., 2025).

Lactobacillus rhamnosus nanoencapsulated using whey protein and zein protein was able to maintain its viability at a significantly higher rate compared to the control sample in the gastrointestinal system and in the fermented product environment of yogurt (Kiran et al., 2023).

It has been stated that zein-based eugenol nanofibers improve the quality parameters of chicken meat while also enhancing its microbiological properties (Ceylan et al., 2025).

Traditionally, probiotic foods require live microorganisms to have beneficial effects, but research shows that inactive (dead) probiotic cells and their metabolic byproducts can also provide health benefits (Franco 2024). It has been stated that heat-inactivated *Lactobacillus rhamnosus* GG is more effective than live probiotic *Lactobacillus rhamnosus* GG in preventing insulin resistance caused by a high-fat and high-fructose diet in rats (Arellano-Garcia et al., 2023).

In another study, postbiotics and parabiotics have emerged as viable alternatives to traditional feed additives.

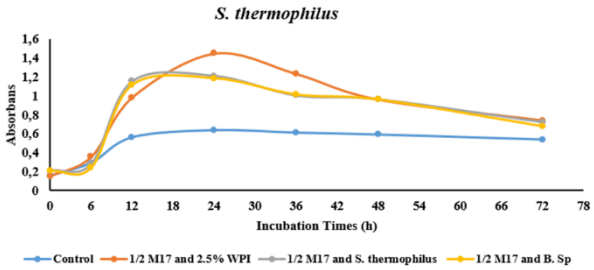

Figure 1. Growth of *S. thermophilus* ATCC 14485 bacteria in different media

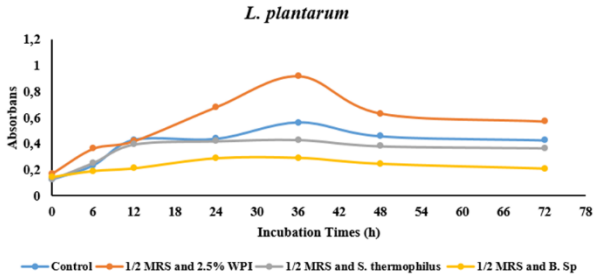

Figure 2. Growth of *L. plantarum* 5102 bacteria in different media

Table 1. Bacteria count results

Test Bacteria	Control	1/2 M17 and 2.5% WPI	1/2 M17 and *S. thermophilus*	1/2 M17 and B. Sp.
S. thermophilus	7.88±0.05	9.67±0.02	8.54±0.06	8.22±0.04
	Control	1/2 MRS and 2.5% WPI	1/2 MRS and *S. thermophilus*	1/2 MRS and B. Sp.
L. plantarum	6.73±0.03	8.42±0.03	5.85±0.01	4.74±0.07

* Test Bacteria were counted according to the absorbance value at which they showed the best growth according to the incubation time (24h for S. thermophilus and 36H for L. plantarum.

Postbiotics are bioactive substances formed after probiotic fermentation, encompassing microbial metabolites such as short-chain fatty acids, peptides, and cell wall fragments, which provide various health benefits. In contrast, parabiotics refer to dead microbial cells or components that provide similar immunomodulatory and gastrointestinal benefits without requiring living organisms. Both interventions play an important role in regulating gut microbiota, enhancing immune function, promoting nutrient absorption, and improving overall growth performance in poultry. The mechanisms by which these compounds exert their beneficial effects include factors such as regulation of the gut microbiota, enhancement of the immune response, and improvement of nutrient absorption (Li et al., 2025).

Parabiotics contain vital metabolites such as lipoteichoic acids, peptidoglycans, short-chain fatty acids, vitamins, and enzymes, which both nutritionally support the viability of active probiotics in the gut microbiota and enhance the competitive strength of probiotic bacteria by exhibiting antimicrobial properties in the environment (Reuben et al., 2021).

For these reasons, new cheap and effective prebiotics are being studied for the protection of probiotics. In this study, we investigated the reusability of non-viable bacterial cells as medium or Prebiotic.

Figure 1. and Figure 2. show the growth of probiotic *S. thermophilus* ATCC 14485 and *L. plantarum* 5102 bacteria during 72h incubation in different media. *S. thermophilus* bacteria increased in number using non-viable bacterial cells up to 12h of incubation, while at 24h and 36h of incubation they showed less growth than in the medium supplemented with 2.5% WPI used as a prebiotic. However, in the last case, it showed a very good improvement compared to the control sample. Vargas et al. (2015) reported that the survival time of *S. thermophilus* ST-M5 bacteria increased in media with 1-3% WPI addition at low pH.

Inulin was used as a prebiotic in a study testing probiotic *S. thermophilus* and *L. rhamnosus* bacteria to improve the quality of dairy products. As a result of the study, the use of inulin as a prebiotic showed a protective effect by stimulating the survival and activity of lactic acid bacteria (Oliveira et al., 2009; de Souza Oliveira et al., 2012).

According to these results, it is seen that both its own and *B*. sp. non-living cells can be used as prebiotics for *S. thermophilus* bacteria.

Whey proteins (WPI, whey protein concentrate (WPC)) have been reported to exert prebiotic effects in the intestinal environment for *Bifidobacterium* and *Lactobacillus* (Sanchez-Moya et al., 2017).

L. plantarum bacteria grown on *B.* sp. and 2.5% WPI medium until 12h of incubation and increased its number approximately. However, it was not able to utilize the *B.* sp. added medium as desired for the rest of the incubation. On the other hand, it could not grow at all in the medium with *S. thermophiles*. The reason for this is thought to be that the metabolites of *B.* sp. and *S. thermophiles* bacteria used as parabiotics cannot meet the growth requirements of *L. plantarum* bacteria, or that an environment that inhibits its growth (low pH, antimicrobial components, etc.) is created.

As a result of this study, WPI seems to be a good prebiotic for *L. plantarum*. However, more studies are needed on why *L. plantarum* cannot utilize other non-living bacterial cells used in the test (*S. thermophilus* and *B.* sp.).

Table 1. The spectrophotometric measurements of *S. thermophilus* and *L. plantarum* bacteria on different media were performed to verify the results of spectrophotometric measurements. To verify the results of the spectrophotometric measurements, petri counts of the bacteria were performed when the absorbance was highest.

The results of the petri count of the bacteria (Table 1) confirm the results of the spectrophotometric measurements (Figure 1 and Figure 2).

Conclusion

In an experiment on the availability of non-living bacterial cells as prebiotics for *S. thermophilus* and probiotic *L. plantarum* bacteria; *S. thermophilus* was able to utilize both its own and non-lactic acid bacteria living *B.* sp. cells, while *L. plantarum* was only partially able to utilize the non-living cells of *S. thermophilus*. For the bacterium *S.*

thermophiles its own non-living cell appeared to be a good prebiotic. The non-living bacterial cells of *S. thermophilus* and probiotic *L. plantarum* can be utilized in fermented and functional foods using *S. thermophilus* as a starter.

Further studies are needed to determine which bacterial cells can be used as parabiotics by which bacteria and whether microorganisms such as yeast and molds can be used as prebiotics by probiotic bacteria.

This study provides a novel insight into the investigation and feasibility of using various parabiotic metabolites to enhance the viability of beneficial bacteria. On the other hand, it highlights the need for more detailed studies on why some bacteria cannot utilize other microorganism metabolites as parabiotics.

Declarations

Ethical Approval Certificate

This study does not require ethical permission.

Author Contribution Statement

A.D.: Corresponding author, Data collection, research, formal analysis and writing of the original manuscript

Fund Statement

The study was not funded by an institution/organization.

Conflict of Interest

There is no conflict of interest in the study.

Acknowledgments

The study was carried out at Bingöl University Bee and Natural Products Ar-Ge and Ur-Ge Application and Research Center

References

Almada, C. N., Almada-Érix, C. N., Bonatto, M. S., Pradella, F., dos Santos, P., Abud, Y. K., & Sant'Ana, A. S. (2021). Obtaining paraprobiotics from Lactobacilus acidophilus, Lacticaseibacillus casei and Bifidobacterium animalis using six inactivation methods: Impacts on the cultivability, integrity, physiology, and morphology. *Journal of Functional Foods*, *87*, 104826. https://doi.org/10.1016/j.jff.2021.104826

Almada, C. N., Almada-Erix, C. N., Roquetto, A. R., Santos-Junior, V. A., Cabral, L., Noronha, M. F., & Sant'Ana, A. S. (2021). Paraprobiotics obtained by six different inactivation processes: impacts on the biochemical parameters and intestinal microbiota of Wistar male rats. *International Journal of Food Sciences and Nutrition*, *72*(8), 1057-1070. https://doi.org/10.1080/09637486.2021.1906211

Arellano-García, L., Macarulla, M. T., Cuevas-Sierra, A., Martínez, J. A., Portillo, M. P., & Milton-Laskibar, I. (2023). Lactobacillus rhamnosus GG administration partially prevents diet-induced insulin resistance in rats: a comparison with its heat-inactivated parabiotic. *Food & Function*, *14*(19), 8865-8875.

Castellone, V., Bancalari, E., Rubert, J., Gatti, M., Neviani, E., & Bottari, B. (2021). Eating fermented: Health benefits of LAB-fermented foods. *Foods*, *10*(11), 2639. https://doi.org/10.3390/foods10112639

Ceylan, Z., Uzun, O., Karaismailoğlu, M. C., Meral, R., & Yildiz, H. B. (2025). The revealing of the Cyto-genotoxic properties (Allium and MTT) and the effect of chicken meat quality of characterized zein-eugenol nanofibers. *Food Chemistry*, *462*, 141043.

Da Silva, N., Taniwaki, M. H., Junqueira, V. C., Silveira, N., Okazaki, M. M., & Gomes, R. A. R. (2018). *Microbiological examination methods of food and water: a laboratory manual*. CRC Press. https://doi.org/10.1201/9781315165011

De Souza Oliveira, R. P., Perego, P., de Oliveira, M. N., & Converti, A. (2012). Effect of inulin on the growth and metabolism of a probiotic strain of Lactobacillus rhamnosus in co-culture with Streptococcus thermophilus. *LWT*, *47*(2), 358-363. https://doi.org/10.1016/j.lwt.2012.01.031

Demirci, A. (2024). Arı Ürünlerinin Nanoteknoloji ve Nanobiyoteknoloji Alanlarinda Kullanim Olanaklari. *Bartın University International Journal of Natural and Applied Sciences*, *7*(2), 151-156.

Demirci, A., Ocak, E., & Ceylan, Z. (2024). A new nanobiotechnology material for yogurt samples: Characterized Nanotubes-Streptococcus thermophilus and Lactobacillus delbrueckii bulgaricus. *Food Bioscience*, *59*, 104178. https://doi.org/10.1016/j.fbio.2024.104178

Demirci, A., Ocak, E., & Ceylan, Z. (2025). Protein-based preservative nanotube: Viability of yogurt bacteria in different environments. *Innovative Food Science & Emerging Technologies*, 104213.

Dicks, L., & Botes, M. (2010). Probiotic lactic acid bacteria in the gastro-intestinal tract: health benefits, safety and mode of action. *Beneficial microbes*, *1*(1), 11-29. https://doi.org/10.3920/BM2009.0012

Ferreira, V. C., Barroso, T. L. C. T., Castro, L. E. N., Da Rosa, R. G., & de Siqueira Oliveira, L. (2023). An overview of prebiotics and their applications in the food industry. *European Food Research and Technology*, *249*(11), 2957-2976. https://doi.org/10.1007/s00217-023-04341-7

Franco, W. (2024). Postbiotics and parabiotics derived from bacteria and yeast: current trends and future perspectives. *CyTA-Journal of Food*, *22*(1), 2425838.

Franco, W. (2024). Postbiotics and parabiotics derived from bacteria and yeast: current trends and future perspectives. *CyTA-Journal of Food*, *22*(1), 2425838.

Harel, M., & Tang, Q. (2023). Protection and delivery of probiotics for use in foods. In *Microencapsulation in the food industry* (pp. 463-480). Academic Press. https://doi.org/10.1016/B978-0-12-821683-5.00026-1

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., & Sanders, M. E. (2014). The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature reviews Gastroenterology & hepatology*, *11*(8), 506-514.

Hosseini, S. H., Farhangfar, A., Moradi, M., & Dalir-Naghadeh, B. (2024). Beyond probiotics: exploring the potential of postbiotics and parabiotics in veterinary medicine. *Research in Veterinary Science*, *167*, 105133.

Kathiriya, M. R., Vekariya, Y. V., & Hati, S. (2023). Understanding the probiotic bacterial responses against various stresses in food matrix and gastrointestinal tract: a review. *Probiotics and Antimicrobial Proteins*, *15*(4), 1032-1048. https://doi.org/10.1007/s12602-023-10104-3

Kiran, F., Afzaal, M., Shahid, H., Saeed, F., Ahmad, A., Ateeq, H., ... & Asif Shah, M. (2023). Effect of protein-based nanoencapsulation on viability of probiotic bacteria under hostile conditions. *International Journal of Food Properties*, *26*(1), 1698-1710.

Kumari, A., KG, R., Sudhakaran. V, A., Warrier, A. S., & Singh, N. K. (2024). Unveiling the health benefits of prebiotics: a comprehensive review. *Indian Journal of Microbiology*, 64(2), 376-388. ttps://doi.org/10.1007/s12088-024-01235-4

Li, Z., Ali, S., Arain, M. A., Hassan, F. U., Nabi, F., Akhtar, M. U., & Yuan, H. (2025). Postbiotics and Parabiotics: A Viable Health Promoting Alternative for Poultry Industry—A Comprehensive Review. *Probiotics and Antimicrobial Proteins*, 1-22.

Nataraj, B. H., Ali, S. A., Behare, P. V., & Yadav, H. (2020). Postbiotics-parabiotics: The new horizons in microbial biotherapy and functional foods. *Microbial cell factories*, *19*, 1-22.

Oliveira, R. P. D. S., Perego, P., Converti, A., & De Oliveira, M. N. (2009). Effect of inulin on growth and acidification performance of different probiotic bacteria in co-cultures and mixed culture with Streptococcus thermophilus. *Journal of Food Engineering*, *91*(1), 133-139. https://doi.org/10.1016/j.jfoodeng.2008.08.013

Orhan, F., Demirci, A., & Gormez, A. (2021). Carbonate and silicate dissolving bacteria isolated from home-made yogurt samples. *Anais da Academia Brasileira de Ciências*, *93*(4), e20200002. https://doi.org/10.1590/0001-3765202120200002

Orhan, F., Demirci, A., Efe, D., Aydın, R., & Bozarı, S. (2024). Usage of ectoine as a cryoprotectant for cryopreservation of lactic acid bacteria. *Folia Microbiologica*, *69*(1), 133-144. https://doi.org/10.1007/s12223-023-01098-0

Parvarei, M. M., Khorshidian, N., Fazeli, M. R., Mortazavian, A. M., Nezhad, S. S., & Mortazavi, S. A. (2021). Comparative effect of probiotic and paraprobiotic addition on physicochemical, chemometric and microstructural properties of yogurt. *Lwt*, *144*, 111177. https://doi.org/10.1016/j.lwt.2021.111177

Peredo, A. G., Beristain, C. I., Pascual, L. A., Azuara, E., & Jimenez, M. (2016). The effect of prebiotics on the viability of encapsulated probiotic bacteria. *Lwt*, *73*, 191-196. https://doi.org/10.1016/j.lwt.2016.06.021

Reuben, R. C., Sarkar, S. L., Roy, P. C., Anwar, A., Hossain, M. A., & Jahid, I. K. (2021). Prebiotics, probiotics and postbiotics for sustainable poultry production. *World's Poultry Science Journal*, *77*(4), 825-882.

Sánchez-Moya, T., López-Nicolás, R., Planes, D., González-Bermúdez, C. A., Ros-Berruezo, G., & Frontela-Saseta, C. (2017). *In vitro* modulation of gut microbiota by whey protein to preserve intestinal health. *Food & function*, *8*(9), 3053-3063. https://doi.org/10.1039/C7FO00197E

Siciliano, R. A., Reale, A., Mazzeo, M. F., Morandi, S., Silvetti, T., & Brasca, M. (2021). Paraprobiotics: A new perspective for functional foods and nutraceuticals. *Nutrients*, *13*(4), 1225. https://doi.org/10.3390/nu13041225

Skrlec, K., Zupančič, Š., Mihevc, S. P., Kocbek, P., Kristl, J., & Berlec, A. (2019). Development of electrospun nanofibers that enable high loading and long-term viability of probiotics. *European Journal of Pharmaceutics and Biopharmaceutics*, *136*, 108-119. https://doi.org/10.1016/j.ejpb.2019.01.013

Taylor, B. C., Lejzerowicz, F., Poirel, M., Shaffer, J. P., Jiang, L., Aksenov, A., & Knight, R. (2020). Consumption of fermented foods is associated with systematic differences in the gut microbiome and metabolome. *Msystems*, *5*(2), 10-1128. https://doi.org/10.1128/msystems.00901-19

Thakur, R., & Kaur, S. (2025). Use of postbiotics and parabiotics from lactobacilli in the treatment of infectious diarrhea. *Microbial Pathogenesis*, 107580.

Vargas, L. A., Olson, D. W., & Aryana, K. J. (2015). Whey protein isolate improves acid and bile tolerances of Streptococcus thermophilus ST-M5 and Lactobacillus delbrueckii ssp. bulgaricus LB-12. *Journal of Dairy Science*, *98*(4), 2215-2221. https://doi.org/10.3168/jds.2014-8869

Verma, S., Gupta, N., Reshi, M., Chib, A., & Kumari, A. (2023). Applıcatıons of probıotıcs and prebıotıcs ın the food ındustry:ARevıew. *Plant Archives (09725210)*, *23*(2). https://doi.org 10.51470/plantarchıves.2023.v23.no2.075

Xu, Y., Zhou, T., Tang, H., Li, X., Chen, Y., Zhang, L., & Zhang, J. (2020). Probiotic potential and amylolytic properties of lactic acid bacteria isolated from Chinese fermented cereal foods. *Food Control*, *111*, 107057. https://doi.org/10.1016/j.foodcont.2019.107057