BÖLÜM 7

SU ÜRÜNLERİNDE PROBİYOTİKLER

Esmeray KÜLEY [1]

GİRİŞ

Probiyotikler, yeterli miktarda alındıklarında konakçı sağlığı üzerinde yararlı etkiler gösteren canlı mikroorganizmalardır (1). Son yıllarda yapılan çok sayıda araştırma, probiyotiklerin yalnızca insan sağlığı üzerindeki etkilerinin değil, aynı zamanda gıdaların korunması ve raf ömrünün uzatılmasında da etkin roller üstlendiğini ortaya koymuştur. Probiyotik mikroorganizmalar; ürettikleri organik asitler, bakteriyosinler, hidrojen peroksit ve diğer antimikrobiyal metabolitler aracılığıyla gıdalarda bozulmaya neden olan mikroorganizmaların gelişimini engelleyerek, hem ürün güvenliğini hem de duyusal ve besinsel kaliteyi korumaktadır (2,3). Bu özellikleri sayesinde probiyotikler, kimyasal koruyuculara doğal, güvenli ve çevre dostu bir alternatif olarak öne çıkmaktadır.

Su ürünleri, yüksek protein içeriği, doymamış yağ asitleri, vitamin ve mineral zenginliği nedeniyle insan beslenmesinde önemli bir yer tutmaktadır. Ancak, bu ürünlerin yüksek su aktivitesi ve nötr pH gibi özellikleri, mikrobiyal gelişmeye elverişli bir ortam oluşturmakta ve hızlı bozulmaya yol açmaktadır. Bu nedenle su ürünlerinde kalite kayıplarının önlenmesi, hem gıda güvenliği hem de ekonomik sürdürülebilirlik açısından kritik öneme sahiptir (4). Geleneksel koruma yöntemleri arasında soğuk zincir uygulamaları, dondurma, tütsüleme, tuzlama ve kimyasal koruyucuların kullanımı yer alsa da, son yıllarda tüketici talebi daha **doğal ve katkısız ürünlere** yönelmiştir. Bu durum, **biyokoruma** kavramının öne çıkmasına ve probiyotiklerin bu alanda yoğun olarak araştırılmasına neden olmuştur.

Su ürünleri ekosisteminden izole edilen probiyotik mikroorganizmalar, çevresel streslere ve tuzluluğa adaptasyon yetenekleri sayesinde balık, kabuklu ve diğer

[1] Prof. Dr., Çukurova Üniversitesi Su Ürünleri Fakültesi, Su Ürünleri Avlama ve İşleme Teknolojisi Bölümü ekuley@cu.edu.tr, ORCID iD: 0000-0001-7886-6566

DOI: 10.37609/akya.3872.c1629

türleri, ürettikleri organik asitler, bakteriyosinler ve antimikrobiyal metabolitler aracılığıyla bozulma mikroorganizmalarının gelişimini engelleyerek ürünlerin raf ömrünü uzatmakta ve kimyasal koruyuculara doğal bir alternatif oluşturmaktadır. Ayrıca, probiyotiklerin antioksidan özellikleri lipid oksidasyonunu yavaşlatmakta, böylece su ürünlerinin duyusal ve besinsel bütünlüğünün korunmasına katkı sağlamaktadır.

Denizel ve tatlı su kaynaklı probiyotik suşların çevresel stres koşullarına adaptasyon yetenekleri, bu mikroorganizmaları su ürünleri endüstrisinde biyokoruyucu ajan olarak daha etkili kılmaktadır. Bununla birlikte, su ürünleri yetiştiriciliğinde probiyotiklerin kullanımı yalnızca ürün muhafazasıyla sınırlı kalmamakta; aynı zamanda balıkların bağırsak mikrobiyotasının dengelenmesi, bağışıklık sisteminin güçlendirilmesi ve hastalık direncinin artırılmasına da katkı sağlamaktadır.

Sonuç olarak, su ürünleri kaynaklı probiyotik kültürlerin hem besin güvenliğini artıran hem de çevre dostu üretim yaklaşımlarını destekleyen çok yönlü bir biyoteknolojik çözüm sunduğu söylenebilir. Gelecekte bu alanda yapılacak çalışmaların, özellikle su ürünlerinden izole edilen yeni probiyotik suşların tanımlanması, fonksiyonel özelliklerinin belirlenmesi ve endüstriyel uygulama süreçlerinin optimize edilmesine odaklanması, gıda teknolojisi ve sürdürülebilir akuakültür açısından büyük önem taşımaktadır.

TEŞEKKÜR

Bu derleme, TÜBİTAK tarafından desteklenen 123O754 ve Çukurova Üniversitesi BAP Koordinatörlüğü tarafından desteklenen FBA-2024-16170 numaralı projeler kapsamında gerçekleştirilmiştir.

KAYNAKLAR

1. El-Saadony, M.T., Alagawany, M., Patra, A.K., et al. The functionality of probiotics in aquaculture: An overview. *Fish Shellfish Immunol*. 2021, 117, 36–52
2. Obafemi, Y. D., Obiukwu, A. C., Oranusi, S. U. Revisiting the application, current trends, and prospect of bacteriocins in food preservation. *Discover Food*, 2025; *5*(1), 165.
3. Parada Fabián, J. C., Álvarez Contreras, A. K., Natividad Bonifacio, I., et al. Toward safer and sustainable food preservation: a comprehensive review of bacteriocins in the food industry. *Bioscience Reports*, 2025; *45*(04), 277-302.
4. Calo-Mata, P., Arlindo, S., Boehme, K., et al. Current applications and future trends of lactic acid bacteria and their bacteriocins for the biopreservation of aquatic food products. *Food and Bioprocess Technology*, 2008; *1*(1), 43-63.
5. Soltani, M., Ghosh, K., Hoseinifar, S. H et al. Genus *Bacillus*, promising probiotics in aquaculture: aquatic animal origin, bio-active components, bioremediation and efficacy in fish and shellfish. *Reviews in Fisheries Science & Aquaculture*, 2019; *27*(3), 331-379
6. Sharma, H., Fidan, H., Özogul, F., et al. Recent development in the preservation effect of lactic

acid bacteria and essential oils on chicken and seafood products. *Frontiers in microbiology*, 2022; *13*, 1092248.

7. .Anumudu, C. K., Miri, T., Onyeaka, H. Multifunctional applications of lactic acid bacteria: Enhancing safety, quality, and nutritional value in foods and fermented beverages. *Foods*, 2024; *13*(23), 3714.
8. Madhulika, Ngasotter, S., Meitei, M. M., et al. Multifaceted role of probiotics in enhancing health and growth of aquatic animals: mechanisms, benefits, and applications in sustainable aquaculture—A Review and Bibliometric Analysis. *Aquaculture nutrition*, *2025*(1), 5746972.
9. Ljungh, A., & Wadstrom, T. Lactic acid bacteria as probiotics. *Current issues in intestinal microbiology*, 2006; 7(2), 73-90.
10. Giri, S.S., Ryu, E.C., Sukumaran, V, et al. Antioxidant, antibacterial, and anti-adhesive activities of biosurfactants isolated from *Bacillus* strains. *Microb. Pathog.* 2019;*132*, 66–72.
11. Abdel-Latif, H. M., Yilmaz, E., Dawood, M. A., et al. Shrimp vibriosis and possible control measures using probiotics, postbiotics, prebiotics, and synbiotics, *Aquaculture*, 2022; *551*, 737951.
12. Henning, C., Vijayakumar, P., Adhikari, R., et al. Isolation and taxonomic identity of bacteriocin-producing Lactic Acid Bacteria from Retail foods and animal sources. *Microorganisms*, 2015; 3, 80–93.
13. Zheng, J., Wittouck, S., Salvetti, E., et al. A taxonomic note on the genus *Lactobacillus*: Description of 23 novel genera, emended description of the genus *Lactobacillus Beijerinck* 1901, and union of *Lactobacillaceae* and *Leuconostocaceae*. *Int. J. Syst. Evol. Microbiol.* 2020; 70, 2782–2858.
14. van Zyl, W.F., Deane, S.M., Dicks, L.M.T. Molecular insights into probiotic mechanisms of action employed against intestinal pathogenic bacteria. *Gut Microbes,* 2020; 12, 1831339
15. Miranda, C., Contente, D., Igrejas, G., et al. Role of exposure to Lactic Acid Bacteria from foods of animal origin in human health. *Foods,* 2021; 10, 2092
16. Castellano, P., Ibarreche, M.P., Massani, M.B., et al. Strategies for pathogen biocontrol using Lactic Acid Bacteria and their metabolites: A focus on meat ecosystems and industrial environments. *Microorganisms*, 2017; 5, 38.
17. Govindaraj, K.; Samayanpaulraj, V.; Narayanadoss, V.; et al. Isolation of Lactic Acid Bacteria from intestine of freshwater fishes and elucidation of probiotic potential for aquaculture application. Probiotics Antimicrob. Proteins 2021, 13, 1598–1610
18. Cheriet, S., Lengliz, S., Romdhani, A., et al. Selection and characterization of bacteriocinogenic Lactic Acid Bacteria from the intestine of gilthead seabream (*Sparus aurata*) and whiting fish (*Merlangius merlangus*): Promising strains for aquaculture probiotic and food bio-preservation. *Life*, 2023; 13(9), 1833.
19. De Vuyst, L, Frédéric L. Bacteriocins from lactic acid bacteria: production, purification, and food applications. *Journal of molecular microbiology and biotechnology* 2007; 13: 194-199.
20. Li, D, Yanping W, Yingchao Z, et al. Evaluation of lactic acid bacteria isolated from alfalfa for silage fermentation. *Grassland Science* 2018, 64: 190-198.
21. Grayfer, L, Kerimoglu, B, Yaparla, A, et al. Mechanisms of fish macrophage antimicrobial immunity. *Frontiers in immunology,* 9, 2018; 1105.
22. Chizhayeva, A, Alma A, Yelena O, et al. Lactic acid bacteria as probiotics in sustainable development of aquaculture." *Aquatic Living Resources,* 35, 2022; 10.
23. Kaktcham, P. M., Temgoua, J. B., Zambou, F. N., et al. In vitro evaluation of the probiotic and safety properties of bacteriocinogenic and non-bacteriocinogenic lactic acid bacteria from the intestines of Nile tilapia and common carp for their use as probiotics in aquaculture. *Probiotics and antimicrobial proteins*, 2018; *10*(1), 98-109.
24. Gálvez, A., Abriouel, H., López, R. L., et al. Bacteriocin-based strategies for food biopreservation. *International journal of food microbiology*, 2007; *120*(1-2), 51-70.
25. Aitzhanova, A., Oleinikova, Y., Mounier, J., et al. Dairy associations for the targeted control of opportunistic Candida. *World Journal of Microbiology and Biotechnology*, 2021; *37*(8), 143.
26. Cortés Sánchez, A.D.J., Díaz Ramírez, M., Salgado Cruz, M.D.L.P. Bioconservation, food and

fish. *Agro Product.* 2018; 11, 11–16

27. Freire, T.T., Tolentino, A.L., Ferreira, B.K.O et al. Lactic acid bacteria its characteristics and importance. *Res. Soc. Dev.* 2021; 10, e513101119964
28. Cortés-Sánchez, A. D. J., Jaramillo-Flores, M. E., Díaz-Ramírez, M., et al. Biopreservation and the safety of fish and fish products, the case of lactic acid bacteria: a basic perspective. *Fishes*, 2024; *9*(8), 303.
29. Lau, L.Y.J., Chye, F.Y. Antagonistic effects of *Lactobacillus* plantarum 0612 on the adhesion of selected foodborne enteropathogens in various colonic environments. *Food Control,* 2018; *91*, 237–247
30. Loghmani, H., Khalili Hadad, B., Kazempoor, R., et al. Investigation of the effects of Bifidobacterium bifidum as a probiotic on liver function enzymes due to exposure to *E. coli* O157H7 in Koi fish (*Cyprinus rubrofuscus*). *J. Surv. Fish. Sci*, 2022; *5*, 27-3.
31. Buntin, N., Chanthachum, S., Hongpattarakere, T. Screening of lactic acid bacteria from gastrointestinal tracts of marine fish for their potential use as probiotics. *Songklanakarin Journal of Science & Technology*, 2008; *30*.
32. Lambuk, F, Nurzafirah M, Tze, YT, et al. Isolation and characterisation of bacteria and fungus from the intestine of sea cucumber *Acaudina molpadioides*. *Malaysian Journal of Fundamental and Applied Sciences* 2023, 19
33. Sorée, M., Kolypczuk, L., Hadjiev, E., et al. Screening of marine lactic acid bacteria for Vibrio parahaemolyticus inhibition and application to depuration in Pacific oysters (*Crassostrea gigas*). *Journal of Applied Microbiology*, 2023; *134*(2), lxac081.
34. Franzmann, P. D., P. Höpfl, N. Weiss, et al. Psychrotrophic, lactic acid-producing bacteria from anoxic waters in Ace Lake, Antarctica; *Carnobacterium funditum* sp. nov. and *Carnobacterium alterfunditum* sp. nov. *Archives of microbiology* 1991;156, 255-262.
35. Mujeeb, I., Ali, S. H., Qambarani, M., et al. Marine Bacteria as Potential Probiotics in Aquaculture. *Journal of microbiology, biotechnology and food sciences*, 2022; *12*(2), e5631-e5631.
36. Riiser, E. S., Haverkamp, T. H., Varadharajan, S., et al. Metagenomic shotgun analyses reveal complex patterns of intra-and interspecific variation in the intestinal microbiomes of codfishes. *Applied and Environmental Microbiology*, 2020; 86(6), e02788-19.
37. Kathiresan, K., G. Thiruneelakandan. Prospects of lactic acid bacteria of marine origin. *Indian J. Biotechnol,* 2008; 7, 170-177.
38. Le François, N. R., C. Drouin-Johnson, F. Dupuis, A. et al. Compensatory growth response of juvenile Arctic charr (*Salvelinus alpinus* L. Nauyuk) under various cyclical food restriction and refeeding periods. *Aquaculture* , 2023;563,738-971.
39. Ringø, E, Seyed HH, Koushik G, et al. Lactic acid bacteria in finfish—An update. *Frontiers in microbiology*, 2018; 1818
40. Resende, LV, Leticia KP, Maria GC, et al. Microbial community and physicochemical dynamics during the production of 'Chicha', a traditional beverage of Indigenous people of Brazil. *World Journal of Microbiology and Biotechnology,* 2018; 34, 46.
41. Neuman, C. "The effect of diet and seasonal variations on the gut microbiota of Tasmanian Atlantic Salmon (*Salmo salar* L.)." PhD diss., University of the Sunshine Coast, 2014.
42. Zhou, S., Song, D., Zhou, X., et al. Characterization of Bacillus subtilis from gastrointestinal tract of hybrid Hulong grouper (*Epinephelus fuscoguttatus*× *E. lanceolatus*) and its effects as probiotic additives. *Fish & Shellfish Immunology*, 2019; *84*, 1115-1124.
43. Coulibaly, W. H., Camara, F., Diguță, C., et al. Functional properties of lactic acid bacteria isolated from Tilapia (Oreochromis niloticus) in Ivory Coast. *BMC microbiology*, 2023; *23*(1), 1-15.
44. Nurhayati, A. P., Zulaika, E., Amin, M., et al. Isolation and screening of lactic acid bacteria producing anti-edwardsiella from the gastrointestinal tract of wild-caught catfish (*Clarias gariepinus*) for probiotic candidates, 2022. https://doi.org/10.21203/rs.3.rs-2081380/v1
45. Fečkaninová, A, Jana K, Dagmar M, et al. Characterization of two novel lactic acid bacteria isolated from the intestine of rainbow trout (*Oncorhynchus mykiss*, Walbaum) in Slovakia. *Aquaculture* 506, 2019, 294-301.

46. Zhang, F., Zhou, K., Xie, F., et al. Screening and identification of lactic acid bacteria with antimicrobial abilities for aquaculture pathogens in vitro. *Archives of Microbiology*, 2022; 204(12), 689.
47. Alonso, S., Carmen Castro, M., Berdasco, M., et al. Isolation and partial characterization of lactic acid bacteria from the gut microbiota of marine fishes for potential application as probiotics in aquaculture. *Probiotics and Antimicrobial Proteins*, 2019; *11*, 569-579.
48. Li, Y., Lu, C., Yu, Z., et al. Isolation of *Enterococcus faecium* with feeding attractant function from Pacific white shrimp (*Litopenaeus vannamei*) intestine. *Journal of Ocean University of China*, 2020; *19*(4), 931-940.
49. Pehlivan, Dilek, and Ertan Emek Onuk. "Gökkuşağı alabalığı bağırsaklarından izole edilen laktik asit bakterilerinin *Lactococcus garvieae*' ye karşı probiyotik potansiyelinin in vitro olarak belirlenmesi. *Journal of Anatolian Environmental and Animal Sciences,* 2020; 5, 647-654.
50. Sahagún-Aguilar, M. L., Villanueva-Rodríguez, S. J., Rincón-Enríquez, G., et al. Isolation and identification of proteolytic lactic-acid bacteria of the common carp (*Cyprinus carpio*) by spontaneous fermentation to obtain functional peptides. *Brazilian Journal of Microbiology*, 2022; *53*(2), 663-672.
51. Peyghan, R., Modaresi, S. M. H., Motevaseli, E., et al. Probiotic properties of some lactic acid bacteria isolated from intestine of cultured common carp, *Cyprinus carpio*, in Khuzestan province. *Iranian Veterinary Journal*, 2022; *18*(1).
52. Cano-Lozano, J. A., Diaz, L. M. V., Bolivar, J. F. M., et al. Probiotics in tilapia (Oreochromis niloticus) culture: Potential probiotic *Lactococcus lactis* culture conditions. *Journal of bioscience and bioengineering*, 2022; *133*(3), 187-194.
53. Seifzadeh, M. Introducing the application of probiotic bacteria to maintain the quality of aquatic fillets. *Journal of Biosafety*, 2022; *15*(3), 15-36.
54. Odeyemi, O.A., Burke, C.M., Bolch, C.C.J., et al. Seafood spoilage microbiota and associated volatile organic compounds at different storage temperatures and packaging conditions. *Int. J. Food Microbiol.* 2018; 280, 87–99.
55. Francoise, L. Occurance and role of lactic acid bacteria in seafood products. *Food Microbiol.* 2010; 27, 698–709
56. Anacarso, I., Messi, P., Condò, C., et al. A bacteriocin-like substance produced from Lactobacillus pentosus 39 is a natural antagonist for the control of *Aeromonas hydrophila* and *Listeria monocytogenes* in fresh salmon fillets. *LWT*, 2014; 55, 604–611.
57. Ibrahim, F., Vesterlund, S. *Lactococcus lactis* ssp. *lactis* as protective culture in vacuum-packed raw salmon (*Salmo salar*). *J. Aquat. Food Prod. Technol.* 2014; 23, 601–607.
58. Gómez-Sala, B., Herranz, C., Díaz-Freitas, B., et al. Strategies to increase the hygienic and economic value of fresh fish: Biopreservation using lactic acid bacteria of marine origin. *International Journal of Food Microbiology*, 2016; 223,41 49.
59. daSilva Vieira, G.R.A., Soares, M., Boliva Ramírez, N.C., et al. Lactic acid bacteria used as preservative in fresh feed for marine shrimp maturation. *Pesq. Agropec. Bras.* 2016; 5, 1799–1805
60. Aymerich, T., Rodríguez, M., Garriga, M., et al. Assessment of the bioprotective potential of lactic acid bacteria against *Listeria monocytogenes* on vacuum-packed cold-smoked salmon stored at 8 C. *Food Microbiol.* 2019, 83, 64–70.
61. Saraoui, T., Cornet, J., Guillouet, E., et al. Improving simultaneously the quality and safety of cooked and peeled shrimp using a cocktail of bioprotective lactic acid bacteria. *Int. J. Food Microbiol.* 2017, 241, 69–77
62. Wiernasz, N., Leroi, F., Chevalier, F., et al. Salmon gravlax biopreservation with lactic acid bacteria: A polyphasic approach to assessing the impact on organoleptic properties, microbial ecosystem and volatilome composition. *Front. Microbiol.* 2020; 10, 3103.
63. Kuley, E., Durmus, M., Ucar, Y., et al. Combined effects of plant and cell-free extracts of lactic acid bacteria on biogenic amines and bacterial load of fermented sardine stored at 3±1 C. *Food bioscience*, 2018; *24*, 127-136.
64. Kuley, E., Kuscu, M. M., Durmus, M., et al. Inhibitory activity of Co-microencapsulation of

cell free supernatant from *Lactobacillus plantarum* with propolis extracts towards fish spoilage bacteria. *LWT Lactobacillus Beijerinck*, 2021; *146*, 111433.

65. Zhang, W.; Lv, X.; Liu, Z.; et al. The spoilage and adhesion inhibitory effects of Bacillus subtilis against Shewanella and Pseudomonas in large yellow croaker (Pseudosciaena crocea). Food Sci. Technol. 2021; 10, 02721.
66. Zhang, W., Tong, Q., You, J., et al. The application of *Bacillus subtilis* for adhesion inhibition of Pseudomonas and preservation of fresh fish. *Foods*, 2021; *10*(12), 3093.
67. Kuley, E., & Özogul, Y. Microbial based preservatives. In *Natural Preservatives for Food*, 2025, pp. 41-70). Academic Press.
68. Suárez, H., Francısco, A. D., Beırão, L. H. Influence of bacteriocins produced by *Lactobacillus plantarum* LPBM10 on shelf life of cachama hybrid fillets *Piaractus rachypomus x Colossoma macropomum*. *Vitae*, 2008; *15*(1), 32-40.
69. Tahiri, I., Desbiens, M., Lacroix, C., et al. Growth of *Carnobacterium divergens* M35 and production of Divergicin M35 in snow crab by product, a natural-grade medium. *LWT Food Science and Technology*, 2009; 42(2), 624 632.
70. Han, J., Liu, Y., Zhu, L., et al. Effects of spraying lactic acid and peroxyacetic acid on the quality and microbial community dynamics of vacuum skin-packaged chilled beef during storage. *Food Research International*, 2021; 142, 110205.
71. Han, J., Meng, X., Shen, H., et al. Purification, molecular characterization of Lactocin 63 produced by *Lactobacillus coryniformis* FZU63 and its antimicrobial mode of action against *Shewanella putrefaciens*. *Applied Microbiology and Biotechnology*, 2021; 105(18), 6921 6930.
72. Khouadja, S., Haddaji, N., Hanchi, M., et al. Selection of lactic acid bacteria as candidate probiotics for *Vibrio parahaemolyticus* depuration in pacific oysters (*Crassostrea gigas*). *Aquaculture Research*, 48(4), 2017; 1885 1894.
73. Corbalán, N., Quiroga, M., Masias, E., et al. Antimicrobial activity of MccJ25 (G12Y) against gram-negative foodborne pathogens in vitro and in food models. *International Journal of Food Microbiology*, 2021; *352*, 109267.
74. Ucar, Y., Özogul, Y., Özogul, F., et al. Effect of nisin on the shelf life of sea bass (*Dicentrarchus labrax* L.) fillets stored at chilled temperature (4±2 C). *Aquaculture International*, 2020; *28*(2), 851-863
75. Angiolillo, L., Conte, A., & Del Nobile, M. A. A new method to bio-preserve sea bass fillets. *International Journal of Food Microbiology*, 2018; *271*, 60-66.
76. Behnam, S., Anvari, M., Rezaei, M., et al. Effect of nisin as a biopreservative agent on quality and shelf life of vacuum packaged rainbow trout (*Oncorhynchus mykiss*) stored at 4 C. *Journal of food science and technology*, 2015; *52*(4), 2184-2192.
77. Butt, U. D., Khan, S., Liu, X., et al. Present status, limitations, and prospects of using *Streptomyces* bacteria as a potential probiotic agent in aquaculture. *Probiotics and Antimicrobial Proteins*, 2024; *16*(2), 426-442.
78. Kuebutornye, F. K., Abarike, E. D., & Lu, Y. A review on the application of Bacillus as probiotics in aquaculture. *Fish & shellfish immunology*, 2019; *87*, 820-828.
79. Mondal, S., Mondal, D., Mondal, T., et al. Application of probiotic bacteria for the management of fish health in aquaculture. In *Bacterial Fish Diseases*, 2022, pp. 351-378. Academic Press.
80. Ringø, Einar, Hien Van Doan, Soon Ho Lee, et al.. Probiotics, lactic acid bacteria and bacilli: interesting supplementation for aquaculture.*Journal of applied microbiology,* 2020;129: 116-136.
81. Nayak, A., Harshitha, M., Disha, S., et al. In vitro determination of probiotic efficacy of *Bacillus subtilis* TLDK301120C24 isolated from tilapia against warm water fish pathogens and in vivo validation using gnotobiotic zebrafish model. 2023, *Microbial Pathogenesis*, *185*, 106429.
82. Yilmaz, S. The effect of dietary cinnamic acid or Bacillus subtilison growth performance and immunological parameters in rainbow trout.PhD Dissertation, 2017, p. 210. Çanakkale Onsekiz Mart University,Graduate School of Natural and Applied Sciences, Türkiye.