

BÖLÜM 7



Ette Mikrobiyolojik Analizler

Seyda ŞAHİN¹

7.1. Giriş

Gıdaların üretimi, işlenmesi ve muhafazası alanında kaydedilen hijyenik ve teknolojik gelişmeler ve tüketici bilincinin yükselmesine rağmen, gıdalardan kaynaklanan enfeksiyonlar hem gelişmiş hem de gelişmekte olan ülkelerde halk sağlığı sorunu olarak önemini korumaktadır (Erol, 2022). Gıdalar farklı kaynaklardan mikrobiyolojik, fiziksel ve kimyasal tehlikelere maruz kalabilmektedir. Bu tehlikeler arasında mikrobiyolojik tehlikeler önemli bir halk sağlığı sorunu oluşturmaktadır. Gıdalarda bulunan patojen mikroorganizmalar (bakteriler, mantarlar, parazitler ve virüsler) veya bunların toksik metabolitleri gıdaların tüketimine bağlı olarak insanlarda önemli sağlık sorunlarına neden olabilmektedir (Erkmen, 2010; Yörük, 2021). Gıda kaynaklı enfeksiyon veya intoksikasyonların çoğu bakteri (*Salmonella enterica*, *Escherichia coli O157:H7*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Campylobacter jejuni*, *Bacillus cereus*, diğer Shiga-toksin üreten *E. coli* suşları, *Brucella* spp., *Yersinia enterocolitica*, *Clostridium perfringens*, *Clostridium botulinum*, *Vibrio parahaemolyticus* ve *Vibrio vulnificus*) ile kontamine gıdaların tüketilmesi sonucunda oluşmaktadır (Dwivedi ve Jaykus, 2011). Gıda kaynaklı enfeksiyon etkenleri arasında

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Kaynaklar

- Acaröz, U., Arslan Acaröz, D. (2021). Et ve et ürünleri mikrobiyolojisi. Hecer C, Editör. Et ve Et Ürünleri. 1. Baskı. Ankara: Türkiye Klinikleri; s.75-78.
- Alves, J., Marques, V.V., Pereira, L.F.P., Hirooka, E.Y., De Oliveira, T.C.R.M. (2012). Multiplex PCR for the detection of *Campylobacter* spp. and *Salmonella* spp. in chicken meat. *Journal of Food Safety*, 32(3), 345-350.
- Amann, R. I., Ludwig, W., Schleifer, K. H. (1995). Phylogenetic identification and in situ detection of individual microbial cells without cultivation. *Microbiological Reviews*, 59(1), 143-169.
- Aran, N., Köseoğlu V.K. (2010). Gıda Mikrobiyolojisi. Aran N, Editör. Gıda Biyoteknolojisi 1. Baskı. Ankara: Nobel Yayın ve Dağıtım; s. 1-17.
- Aras, Z. (2011). Mikrobiyolojide kullanılan hızlı tanı yöntemleri. *Türk Hijyen ve Deneysel Biyoloji Dergisi*, 68(2), 97-104.
- Arda, M. (2000). Nukleik Asitlerin İn Vitro Amplifikasyon Yöntemleri In: Temel Mikrobiyoloji. 2. Baskı, Medisan Yayınları, Ankara.
- Arslan, A. (2020). Et Muayenesi ve Et Ürünleri Teknolojisi. 3. Baskı, Medipress Yayıncılık, Malatya.
- Aydin, A., Sudagidan, M., Muratoglu, K. (2011). Prevalence of staphylococcal enterotoxins, toxin genes and genetic-relatedness of foodborne *Staphylococcus aureus* strains isolated in the Marmara Region of Turkey. *International Journal of Food Microbiology*, 148(2), 99-106.
- Aydin, A., Sudağıdan, M. (2016). Gıda mikrobiyolojisinde moleküler biyolojik tekniklerin kullanımı ve tiplendirme yöntemleri. *Türkiye Klinikleri Gıda Hijyenİ ve Teknolojisi Özel Dergisi*, 2(1), 1-9.
- Aznar, R., Alarcón, B. (2003). PCR detection of *Listeria monocytogenes*: a study of multiple factors affecting sensitivity. *Journal of Applied Microbiology*, 95(5), 958-966.
- Bahadir, E. B., Sezgintürk, M. K. (2016). Lateral flow assays: Principles, designs and labels. *TrAC Trends in Analytical Chemistry*, 82, 286-306.
- Bal, S.H., Budak, F. (2012). Mikroarray teknolojisi. Uludağ Üniversitesi Tip Fakültesi Dergisi, 38(3), 227-233.
- Barbau-Piednoir, E., Botteldoorn, N., Yde, M., Mahillon, J., & Roosens, N. H. (2013). Development and validation of qualitative SYBR® Green real-time PCR for detection and discrimination of *Listeria* spp. and *Listeria monocytogenes*. *Applied Microbiology and Biotechnology*, 97(9), 4021-4037.
- Bartlett, J.M.S., Stirling, D. (2003). A Short History of the Polymerase Chain Reaction. In: Bartlett J.M.S., Stirling D. Editors, PCR Protocols. Methods in Molecular Biology, Vol; 226. Humana Press, pp. 3-6.
- Baş, D., Deniz, E. (2015). Gıda güvenliği ve kalite kontrolünde biyosensörler. *Gıda*, 40(4), 225-232.
- Beneduce, L., Fiocco, D., Spano, G. (2007). Development of PCR-based molecular tools for the detection of emerging food-ad water-borne pathogenic bacteria. Méndez-Vilas A, Editor, *Communicating Current Research and Educational Topics and Trends in Applied Microbiology*, p. 569-576.
- Bi, Y., Shu, M., Zhong, C., Li, S. Y., Li, Y. K., Yang, H. H., Wu, G. P. (2020). A novel SDS rinse and immunomagnetic beads separation combined with real-time loop-mediated isothermal amplification for rapid and sensitive detection of *Salmonella* in ready-to-eat duck meat. *Food Analytical Methods*, 13(5), 1166-1175.

- Böhmer, A., Schildgen, V., Lüsebrink, J., Ziegler, S., Tillmann, R. L., Kleines, M., Schildgen, O. (2009). Novel application for isothermal nucleic acid sequence-based amplification (NASBA). *Journal of Virological Methods*, 158(1-2), 199-201.
- Cheng, L. W., Stanker, L. H. (2013). Detection of botulinum neurotoxin serotypes A and B using a chemiluminescent versus electrochemiluminescent immunoassay in food and serum. *Journal of Agricultural and Food Chemistry*, 61(3), 755-760.
- Chen, J., Griffiths, M.W. 1998. PCR differentiation of *Escherichia coli* from other Gram-negative bacteria using primers derived from the nucleotide sequences flanking the gene encoding the universal stress protein. *Letters in Applied Microbiology*, 27(6), 369-371.
- Chen, X., Gan, M., Xu, H., Chen, F., Ming, X., Xu, H., Liu, C. (2014). Development of a rapid and sensitive quantum dot-based immunochromatographic strip by double labeling PCR products for detection of *Staphylococcus aureus* in food. *Food Control*, 46, 225-232.
- Chen, Z., Zhang, K., Yin, H., Li, Q., Wang, L., Liu, Z. (2015). Detection of *Salmonella* and several common *Salmonella* serotypes in food by loop-mediated isothermal amplification method. *Food Science and Human Wellness*, 4(2), 75-79.
- Ching, K. H., He, X., Stanker, L. H., Lin, A. V., McGarvey, J. A., Hnasko, R. (2015). Detection of shiga toxins by lateral flow assay. *Toxins*, 7(4), 1163-1173.
- Cho, I. H., Irudayaraj, J. (2013). Lateral-flow enzyme immunoconcentration for rapid detection of *Listeria monocytogenes*. *Analytical and Bioanalytical Chemistry*, 405(10), 3313-3319.
- Churruga, E., Girbau, C., Martinez, I., Mateo, E., Alonso, R., Fernandez-Astorga, A. (2007). Detection of *Campylobacter jejuni* and *Campylobacter coli* in chicken meat samples by real-time nucleic acid sequence-based amplification with molecular beacons. *International Journal of Food Microbiology*, 117(1), 85-90.
- Compton, J. (1991). Nucleic acid sequence-based amplification. *Nature*, 350, 91-92.
- Cook, N. (2003). The use of NASBA for the detection of microbial pathogens in food and environmental samples. *Journal of Microbiological Methods*, 53(2), 165-174.
- Coutou, J., Morissette, C., D'auria, S., Lacroix, M. (2014). Development of a highly specific sandwich ELISA for the detection of *Listeria monocytogenes*, an important foodborne pathogen. *Microbiology Research International*, 2(4), 46-52.
- D'agostino, M., Wagner, M., Vazquez-Boland, J. A., Kuchta, T., Karpiskova, R., Hoofar, J., ... Cook, N. (2004). A validated PCR-based method to detect *Listeria monocytogenes* using raw milk as a food model towards an international standard. *Journal of Food Protection*, 67(8), 1646-1655.
- Demir, T., Ağaoğlu, S. (2021). Presence of tetracycline-group of antibiotics in the eggs coded according to the cultivation method. *Fırat Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi*, 35(1), 43-47.
- Doğruer, Y., Telli, A.E. (2020). Determination of *Vibrio parahaemolyticus* in seafoods using direct plate counting, quantitative loop-mediated isothermal amplification and propidium monoazide-qLAMP. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, 67(4), 349-355.
- Dwivedi, H. P., & Jaykus, L. A. (2011). Detection of pathogens in foods: the current state-of-the-art and future directions. *Critical Reviews in Microbiology*, 37(1), 40-63.
- Eischeid, A.C. (2011). SYTO dyes and EvaGreen outperform SYBR Green in real-time PCR. *BMC Research Notes*, 4(1), 1-5.
- Erkmen, O. (2010). Gıda kaynaklı tehlükeler ve güvenli gıda üretimi. *Çocuk Sağlığı ve Hastalıkları Dergisi*, 53(3), 220-235.
- Erol, İ. (2022). Gıda Kaynaklı Patojenlerin Epidemiyolojisi. In: Gıda Hijyenİ ve Mikrobiyolojisi. Genişletilmiş 2. Baskı, Ankara Nobel Tip Kitapevleri, Ankara, s. 53-74.

- Espy, M. J., Uhl, J. R., Sloan, L. M., Buckwalter, S. P., Jones, M. F., Vetter, E. A., ... Smith, T. (2006). Real-time PCR in clinical microbiology: applications for routine laboratory testing. *Clinical Microbiology Reviews*, 19(1), 165-256.
- Fratamico, P.M., Kawasaki, S. (2008). Applications of the polymerase chain reaction for detection, identification, and typing of foodborne microorganisms. In: Microbial Food Contamination, Wilson, C.L. Editor, CRC Press Publishers, New York, p. 213-254.
- Fricker, M., Messelhäußer, U., Busch, U., Scherer, S., Ehling-Schulz, M. (2007). Diagnostic real-time PCR assays for the detection of emetic *Bacillus cereus* strains in foods and recent food-borne outbreaks. *Applied and Environmental Microbiology*, 73(6), 1892-1898.
- Fung, D.Y.C. (2002). Rapid methods and automation in microbiology. Comprehensive Reviews in Food Science and Food Safety, 1(1), 3-22.
- Fung, D. (2009). Rapid methods and automation in food microbiology: 25 years of development and predictions. In: *Global Issues in Food Science and Technology*, Academic Press, p. 165-176.
- Fykse, E. M., Skogan, G., Davies, W., Olsen, J. S., Blatny, J. M. (2007). Detection of *Vibrio cholerae* by real-time nucleic acid sequence-based amplification. *Applied and Environmental Microbiology*, 73(5), 1457-1466.
- Garrido-Maestu, A., Fuciños, P., Azinheiro, S., Carvalho, J., & Prado, M. (2017). Systematic loop-mediated isothermal amplification assays for rapid detection and characterization of *Salmonella* spp., Enteritidis and Typhimurium in food samples. *Food Control*, 80, 297-306.
- Garrido-Maestu, A., Azinheiro, S., Carvalho, J., Prado, M. (2018). Rapid and sensitive detection of viable *Listeria monocytogenes* in food products by a filtration-based protocol and qPCR. *Food Microbiology*, 73, 254-263.
- Glynn, B., Lahiff, S., Wernecke, M., Barry, T., Smith, T. J., Maher, M. (2006). Current and emerging molecular diagnostic technologies applicable to bacterial food safety. *International Journal of Dairy Technology*, 59(2), 126-139.
- Gürsoy, N.C., Barış, O. (2017). Mikrobiyota çalışmalarında moleküler tanı yöntemleri. *Journal of Biotechnology and Strategic Health Research*, 1, 56-67.
- Güven, E., Azizoglu, R.O. (2022). The recent original perspectives on nonculture-based bacteria detection methods: A comprehensive review. *Foodborne Pathogens and Disease*. <http://doi.org/10.1089/fpd.2021.0078>.
- Hahm BK, Bhunia AK. 2006. Effect of environmental stresses on antibody-based detection of *Escherichia coli* O157:H7, *Salmonella enterica* serotype Enteritidis and *Listeria monocytogenes*. *Journal of Applied Microbiology*, 100: 1017-1027.
- Halkman, A.K. (2013). Gıda Mikrobiyolojisi II ders notları. Ankara Üniversitesi, Mühendislik Fakültesi, Gıda Mühendisliği Bölümü, Ankara, s. 89.
- Han, F., Ge, B. (2010). Quantitative detection of *Vibrio vulnificus* in raw oysters by real-time loop-mediated isothermal amplification. *International Journal of Food Microbiology*, 142(1-2), 60-66.
- Hanna, S.E., Connor, C.J., Wang, H.H. (2005). Real-time polymerase chain reaction for the food microbiologist: technologies, applications, and limitations. *Journal of Food Science*, 70(3), R49-R53.
- He, X., Kong, Q., Patfield, S., Skinner, C., Rasooly, R. (2016). A new immunoassay for detecting all subtypes of Shiga toxins produced by Shiga toxin-producing *E. coli* in ground beef. *PLoS one*, 11(1), e0148092.
- Helali, S., Sawelem Eid Alatawi, A., Abdelghani, A. (2018). Pathogenic *Escherichia coli* biosensor detection on chicken food samples. *Journal of Food Safety*, 38(5), e12510.

- Holland, P. M., Abramson, R. D., Watson, R., Gelfand, D. H. (1991). Detection of specific polymerase chain reaction product by utilizing the 5'----3'exonuclease activity of *Thermus aquaticus* DNA polymerase. *Proceedings of the National Academy of Sciences*, 88(16), 7276-7280.
- Hu, Q., Lyu, D., Shi, X., Jiang, Y., Lin, Y., Li, Y., ... Li, Q. (2014). A modified molecular beacons-based multiplex real-time PCR assay for simultaneous detection of eight foodborne pathogens in a single reaction and its application. *Foodborne Pathogens and Disease*, 11(3), 207-214.
- Kahya Demirbilek, S., Gurcan, H., Yilmaz, O. (2016). PCR and ELISA for staphylococcal enterotoxins and detection of some exotoxins from *Staphylococcus* spp. strains by PCR. *Medyanya Veterinaria-Veterinary Medicine-Science and Practice*, 72 (1), 28-33.
- Kevenk, T.O., Koluman, A. (2022). Method validation and prevalence of *L. monocytogenes* contamination in ground beef with VIDAS: as an alternative method compared with ISO 11290. *Fresenius Environmental Bulletin*, 31(2), 2305-2311.
- Khan, M., Nazir, J., Anjum, A. A., Nawaz, M., & Shabbir, M. Z. (2015). Toxinotyping and antimicrobial susceptibility of enterotoxigenic *Clostridium perfringens* isolates from mutton, beef and chicken meat. *Journal of Food Science and Technology*, 52(8), 5323-5328.
- Kocaman, N., Sarımehmetoğlu, B. (2017). Kuzu etlerinden *Listeria monocytogenes* izolasyonu ve antibiyotik dirençliliklerinin belirlenmesi. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, 64(4), 273-279.
- Kralik, P., Ricchi, M. (2017). A basic guide to real time PCR in microbial diagnostics: definitions, parameters, and everything. *Frontiers in Microbiology*, 8, 108.
- Lauri, A., Mariani, P.O. (2009). Potentials and limitations of molecular diagnostic methods in food safety. *Genes & Nutrition*, 4(1), 1-12.
- Law, J. W. F., Ab Mutalib, N. S., Chan, K. G., Lee, L. H. (2015). Rapid methods for the detection of foodborne bacterial pathogens: principles, applications, advantages and limitations. *Frontiers in Microbiology*, 5(770), 1-19.
- Lee, N., Kwon, K.Y., Oh, S. K., Chang, H.J., Chun, H. S., Choi, S.W. (2014). A multiplex PCR assay for simultaneous detection of *Escherichia coli* O157: H7, *Bacillus cereus*, *Vibrio parahaemolyticus*, *Salmonella* spp., *Listeria monocytogenes*, and *Staphylococcus aureus* in Korean ready-to-eat food. *Foodborne Pathogens and Disease*, 11(7), 574-580.
- Levin, R.E. (2004). The application of real-time PCR to food and agricultural systems. A review. *Food Biotechnology*, 18(1), 97-133.
- Li, Y., Liu, D., Cao, B., Han, W., Liu, Y., Liu, F., ... & Wang, L. (2006). Development of a serotype-specific DNA microarray for identification of some *Shigella* and pathogenic *Escherichia coli* strains. *Journal of Clinical Microbiology*, 44(12), 4376-4383.
- Lilja, L., Hanninen, M. L. (2001). Evaluation of a commercial automated ELISA and PCR-method for rapid detection and identification of *Campylobacter jejuni* and *C. coli* in poultry products. *Food Microbiology*, 18(2), 205-209.
- Liu, D., Lawrence, M.L., Ainsworth, A.J. Austin, F.W. (2008). Genotypic Identification. In: *Handbook of Listeria monocytogenes*, Liu D, Editor, CRC Press, New York, USA, p. 169-203.
- Liu, C.C., Yeung, C.Y., Chen, P. H., Yeh, M.K., Hou, S.Y. (2013). *Salmonella* detection using 16S ribosomal DNA/RNA probe-gold nanoparticles and lateral flow immunoassay. *Food Chemistry*, 141(3), 2526-2532.
- Malorny, B., Hoofar, J., Bunge, C., Helmuth, R. (2003). Multicenter validation of the analytical accuracy of *Salmonella* PCR: towards an international standard. *Applied and environmental microbiology*, 69(1), 290-296.
- Mandal, P.K., Biswas, A.K., Choi, K., Pal, U.K. (2011). Methods for rapid detection of foodborne pathogens: an overview. *American Journal of Food Technology*, 6(2), 87-102.
- Markoulatos, P., Siafakas, N., Moncany, M. (2002). Multiplex polymerase chain reaction: a practical approach. *Journal of Clinical Laboratory Analysis*, 16(1), 47-51.

- Maruyama, F., Kenzaka, T., Yamaguchi, N., Tani, K., Nasu, M. (2003). Detection of bacteria carrying the stx 2 gene by in situ loop-mediated isothermal amplification. *Applied and Environmental Microbiology*, 69(8), 5023-5028.
- Maurischat, S., Baumann, B., Martin, A., Malorny, B. (2015). Rapid detection and specific differentiation of *Salmonella enterica* subsp. *enterica* Enteritidis, Typhimurium and its monophasic variant 4,[5], 12: i:- by real-time multiplex PCR. *International Journal of Food Microbiology*, 193, 8-14.
- Mei, Y., He, C., Zeng, W., Luo, Y., Liu, C., Yang, M.,....Huang, Q. (2022). Electrochemical biosensors for foodborne pathogens detection based on carbon nanomaterials: recent advances and challenges. *Food and Bioprocess Technology*, 1-16.
- Meyer, C., Thiel, S., Ullrich, U., Stolle, A. (2010). *Salmonella* in raw meat and by-products from pork and beef. *Journal of Food Protection*, 73(10), 1780-1784.
- Min, J., Baeumner, A. J. (2002). Highly sensitive and specific detection of viable *Escherichia coli* in drinking water. *Analytical Biochemistry*, 303(2), 186-193.
- Moon, Y. J., Lee, S. Y., Oh, S. W. (2022). A review of isothermal amplification methods and food-origin inhibitors against detecting food borne pathogens. *Foods*, 11(3), 322, 2-15.
- Muti İstek, M., Bulca, S. (2021). Gıda kontaminantlarının analizine yönelik elektrokimyasal biyosensör uygulamaları. *Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 12(Ek Suppl.) 1), 532-544.
- Nagamine, K., Kuzuhara, Y. and Notomi, T. (2002). Isolation of single-stranded DNA from loop-mediated isothermal amplification products. *Biochemical and Biophysical Research Communications*, 290 (4), 1195-1198.
- Nodoushan, S. M., Nasirizadeh, N., Amani, J., Halabian, R., Fooladi, A.A.I. (2019). An electrochemical aptasensor for staphylococcal enterotoxin B detection based on reduced graphene oxide and gold nano-urchins. *Biosensors and Bioelectronics*, 127, 221-228.
- Notomi, T., Okayama, H., Masubuchi, H., Yonekawa, T., Watanabe, K., Amino, N., Hase, T. (2000). Loop-mediated isothermal amplification of DNA. *Nucleic Acids Research*, 28 (12), e63.
- Notomi, T., Mori, Y., Tomita, N., Kanda, H. (2015). Loop-mediated isothermal amplification (LAMP): principle, features, and future prospects. *Journal of Microbiology*, 53(1), 1-5.
- Ohk, S.H., Bhunia, A.K. (2013). Multiplex fiber optic biosensor for detection of *Listeria monocytogenes*, *Escherichia coli* O157: H7 and *Salmonella enterica* from ready-to-eat meat samples. *Food Microbiology*, 33(2), 166-171.
- Özatay, Ş. (2012). Moleküler metodların gıda kontrollerindeki uygulama alanları. *Türk Bilimsel Derlemeler Dergisi*, 5(1), 75-81.
- Özşensoy, Y., Şahin, S. (2016). Comparison of different DNA isolation methods and use of dodecyle trimethyl ammonium bromide (DTAB) for the isolation of DNA from meat products. *Journal of Advanced Veterinary and Animal Research*, 3, 368-374.
- Öztürk, U., Gürbüz, Ü., Çalım, H. D. (2006). Et ve et ürünlerinde mikrobiyolojik kriterler ve halk sağlığı açısından önemi. Türkiye 9. Gıda Kongresi, 24-26 Mayıs, Bolu.
- Ryu, J., Park, S. H., Yeom, Y. S., Shrivastav, A., Lee, S. H., Kim, Y. R., & Kim, H. Y. (2013). Simultaneous detection of *Listeria* species isolated from meat processed foods using multiplex PCR. *Food Control*, 32(2), 659-664.
- Qin, Y., Puthiyakunnon, S., Zhang, Y., Wu, X., Boddu, S., Luo, B., Fan, H. (2018). Rapid and specific detection of *Escherichia coli* O157: H7 in ground beef using immunomagnetic separation combined with loop-mediated isothermal amplification. *Polish Journal of Food and Nutrition Sciences*, 68(2), 115-123.
- Sahin, S., Kalin, R., Mogulkoc, M.N. (2019). Distribution of serotypes of *Listeria monocytogenes* in chicken meats in Turkey. *Journal of the Hellenic Veterinary Medical Society*, 70(4), 1859-1864.

- Sahin, S., Mogulkoc, M. N., Kalin, R., Karahan, M. (2020b). Determination of the important toxin genes of *Staphylococcus aureus* isolated from meat samples, food handlers and food processing surfaces in Turkey. *Israel Journal of Veterinary Medicine*, 75(2), 42-49.
- Sahin, S. (2020). Determination of the ciprofloxacin-resistant *Escherichia coli* isolated from chicken meat in Turkey. *Journal of the Hellenic Veterinary Medical Society*, 71(3), 2291-2300.
- Severgnini, M., Cremonesi, P., Consolandi, C., De Bellis, G., Castiglioni, B. (2011). Advances in DNA microarray technology for the detection of foodborne pathogens. *Food and Bioprocess Technology*, 4(6), 936-953.
- Sewell, A. M., Warburton, D. W., Boville, A., Daley, E. F., Mullen, K. (2003). The development of an efficient and rapid enzyme linked fluorescent assay method for the detection of *Listeria* spp. from foods. *International Journal of Food Microbiology*, 81(2), 123-129.
- Shan, S., Lai, W., Xiong, Y., Wei, H., Xu, H. (2015). Novel strategies to enhance lateral flow immunoassay sensitivity for detecting foodborne pathogens. *Journal of Agricultural and Food Chemistry*, 63(3), 745-753.
- Shao, Y., Zhu, S., Jin, C., Chen, F. (2011). Development of multiplex loop-mediated isothermal amplification-RFLP (mLAMP-RFLP) to detect *Salmonella* spp. and *Shigella* spp. in milk. *International journal of Food Microbiology*, 148(2), 75-79.
- Silva, N. F., Neves, M. M., Magalhães, J. M., Freire, C., Delerue-Matos, C. (2020). Emerging electrochemical biosensing approaches for detection of *Listeria monocytogenes* in food samples: An overview. *Trends in Food Science Technology*, 99, 621-633.
- Şahin, S., Kalın, R., Arslanbaş, E., Moğulköç, M.N. (2017). Satış sunulan tavuk etlerinde bazı bakteri ve indikatör mikroorganizmaların belirlenmesi. *Manas Journal of Agriculture Veterinary and Life Sciences*, 7(1), 47-56.
- Şahin, S., Moğulköç, M.N., Kalın, R. (2020a). Prevalence and serotype distribution of *Listeria monocytogenes* isolated from retail raw meats. *Erciyes Üniversitesi Veteriner Fakültesi Dergisi*, 17(1), 22-27.
- Taha, E.G., Mohamed, A., Srivastava, K.K., Reddy, P.G. (2010). Rapid detection of *Salmonella* in chicken meat using immunomagnetic separation, CHROMagar, ELISA and real-time polymerase chain reaction (RT-PCR). *International Journal of Poultry Science*, 9(831), e835.
- Tekintaş, Y., Hoşgör-Limoncu, M. (2018). Bakteriyoloji alanında kullanılan modern tanı yöntemleri: hızlı ve etkili. *Klinik Dergisi*, 31(3), 176-80.
- Telli, A. E., Doğrular, Y. (2019). Discrimination of viable and dead *Vibrio parahaemolyticus* subjected to low temperatures using propidium monoazide-quantitative loop mediated isothermal amplification (PMA-qLAMP) and PMA-qPCR. *Microbial Pathogenesis*, 132, 109-116.
- Temizkan, G., Arda, N. (2004). Moleküler Biyolojide Kullanılan Yöntemler, Nobel Tip Kitapevleri, Genişletilmiş 2. Baskı, İstanbul.
- TGK (2011). Türk Gıda Kodeksi, Mikrobiyolojik Kriterler Tebliği, Sayı: 28145, Tarih: 29 Aralık 2011, Resmi Gazete, Başbakanlık Basımevi, Ankara.
- TGK (2012). Türk Gıda Kodeksi Et ve Et Ürünleri Tebliği. Sayı: 28488, Tarih: 5 Aralık 2012, Resmi Gazete, Başbakanlık Basımevi, Ankara.
- Tutar, E., Köksalan, E., Akyol, İ. (2015). Gidalarda bulunan mikrobiyal patojenlerin karakterizasyonunda real time PCR teknolojisi. *KSÜ Doğa Bilimleri Dergisi*, 18(4), 26-39.
- Tüylek, Z. (2017). Biyosensörler ve nanoteknolojik etkileşim. *Bitlis Eren Üniversitesi Fen Bilimleri Dergisi*, 6(2), 71-80.
- Uyttendaele, M., Schukkink, R., Van Gemen, B., Debevere, J. (1995). Development of NASBA®, a nucleic acid amplification system, for identification of *Listeria monocytogenes* and comparison to ELISA and a modified FDA method. *International Journal of Food Microbiology*, 27(1), 77-89.

- Vaz-Velho, M., Duarte, G., Gibbs, P. (2000). Evaluation of mini-VIDAS rapid test for detection of *Listeria monocytogenes* from production lines of fresh to cold-smoked fish. *Journal of Microbiological Methods*, 40(2), 147-151.
- Velusamy, V., Arshak, K., Korostynka, O., Vaseashta, A., Adley C. (2012). Real time detection of foodborne pathogens for food quality monitoring biosecurity. In: Vaseashta AT, Braman E, Susmann P, eds. Technological innovations in sensing and detection of chemical, biological terrorism. Dordrecht: Springer Publishing; p.149-58.
- Wang, X. W., Zhang, L., Jin, L. Q., Jin, M., Shen, Z. Q., An, S., ... Li, J. W. (2007). Development and application of an oligonucleotide microarray for the detection of food-borne bacterial pathogens. *Applied Microbiology and Biotechnology*, 76(1), 225-233.
- Wang, L., Shi, L., Alam, M. J., Geng, Y., Li, L. (2008). Specific and rapid detection of foodborne *Salmonella* by loop-mediated isothermal amplification method. *Food Research International*, 41(1), 69-74.
- Wang, D. G., Brewster, J. D., Paul, M., Tomasula, P. M. (2015b). Two methods for increased specificity and sensitivity in loop-mediated isothermal amplification. *Molecules*, 20(4), 6048-6059.
- Wang, Y., Wang, Y., Ma, A., Li, D., Luo, L., Liu, D., ... Ye, C. (2015b). The novel multiple inner primers-loop-mediated isothermal amplification (MIP-LAMP) for rapid detection and differentiation of *Listeria monocytogenes*. *Molecules*, 20(12), 21515-21531.
- Wang, Z., Cai, R., Gao, Z., Yuan, Y., & Yue, T. (2020a). Immunomagnetic separation: An effective pretreatment technology for isolation and enrichment in food microorganisms detection. *Comprehensive Reviews in Food Science and Food Safety*, 19(6), 3802-3824.
- Wang, S., Sun, C., Hu, Q., Li, S., Wang, C., Wang, P., & Zhou, L. (2020b). A homogeneous magnetic bead-based impedance immunosensor for highly sensitive detection of *Escherichia coli* O157: H7. *Biochemical Engineering Journal*, 156, 107513.
- Wang, Y., He, D., Du, Z., Xu, E., Jin, Z., Wu, Z., Cui, B. (2022). Ultrasensitive detection of Staphylococcal Enterotoxin B with an AuNPs@ MIL-101 nanohybrid-based dual-modal apta-sensor. *Food Analytical Methods*, 1-9.
- Wu, Q., Zhang, Y., Yang, Q., Yuan, N., & Zhang, W. (2019). Review of electrochemical DNA biosensors for detecting food borne pathogens. *Sensors*, 19(22), 4916.
- Xu, X., Ying, Y. (2011). Microbial biosensors for environmental monitoring and food analysis. *Food Reviews International*, 27(3), 300-329.
- Yalçın, H. (2016). Gıda analizlerinde immunoassay (VIDAS, TEMPO, VITEK) ve ELISA yöntemlerinin kullanımı. *Türkiye Klinikleri Gıda Hijyenİ ve Teknolojİ ÖZEL Dergisi*, 2(1): 10-22.
- Yamazaki, W., Ishibashi, M., Kawahara, R., Inoue, K. (2008). Development of a loop-mediated isothermal amplification assay for sensitive and rapid detection of *Vibrio parahaemolyticus*. *BMC Microbiology*, 8(1), 1-7.
- Ye, Y., Wang, B., Huang, F., Song, Y., Yan, H., Alam, M. J., ... Shi, L. (2011). Application of in situ loop-mediated isothermal amplification method for detection of *Salmonella* in foods. *Food Control*, 22(3-4), 438-444.
- Yelboğa, E., Karagüler, N.G. (2010). Moleküler biyolojik yöntemler. Aran N, Editör. Gıda Biyoteknolojisi. 1. Baskı Ankara: Nobel Yayın Dağıtım; p. 49-69.
- Yilmaz, T. (2021). Gıda ürünlerinde mikrobiyal bozulmaya neden olan *Pseudomonas* spp. bakterisinin yüzey plazmon rezonans (SPR) temelli biyosensör kullanılarak belirlenmesi (Hacettepe Üniversitesi Biyomühendislik Alanı, Yüksek Lisans Tezi), Ankara, s. 111.
- Yonekita, T., Ohtsuki, R., Hojo, E., Morishita, N., Matsumoto, T., Aizawa, T., Morimatsu, F. (2013). Development of a novel multiplex lateral flow assay using an antimicrobial peptide for the detection of Shiga toxin-producing *Escherichia coli*. *Journal of Microbiological Methods*, 93(3), 251-256.

- Yörük., N.G. (2021). Gıda Güvenliği ve Mikrobiyel Risk Faktörleri. In: Gıda Güvenliği ve Güncel Uygulamalar. Güner, A. Editör. Sidas Medya, İzmir. s.1-36
- Yüksel, M., Sert, S., Kavaz Yüksel, A., Çetin, B., Gürses, M. (2022). Kolorimetrik loop-mediated izotermal amplifikasyon metodu ile *Listeria monocytogenes*'in tavuk etlerinde hızlı tespiti. *Gıda*, 47(1), 121-135.
- Zende, R.J., Kshirsagar, D.P., Vaidya, V.M., Waghmare, R.N., Todankar, R.P., Shirke, A.H. (2017). Loop-Mediated Isothermal Amplification assay (LAMP): a rapid tool for diagnosis of food borne and zoonotic pathogens: a review. *International Journal of Livestock Research*, 7(5), 23-35.
- Zhou, B., Xiao, J., Liu, S., Yang, J., Wang, Y., Nie, F., ... Zhao, G. (2013). Simultaneous detection of six food-borne pathogens by multiplex PCR with a GeXP analyzer. *Food Control*, 32(1), 198-204.
- Zhao, X., He, X., Li, W., Liu, Y., Yang, L., Wang, J. (2010). Development and evaluation of colloidal gold immunochromatographic strip for detection of *Escherichia coli* O157. *African Journal of Microbiology Research*, 4(9), 663-670.
- Zhao, X., Lin, C. W., Wang, J., Oh, D. H. (2014). Advances in rapid detection methods for food-borne pathogens. *Journal of microbiology and biotechnology*, 24(3), 297-312.
- Zhai, L., Liu, H., Chen, Q., Lu, Z., Zhang, C., Lv, F., Bie, X. (2019). Development of a real-time nucleic acid sequence-based amplification assay for the rapid detection of *Salmonella* spp. from food. *Brazilian Journal of Microbiology*, 50(1), 255-261.
- Zhu, L., He, J., Cao, X., Huang, K., Luo, Y., Xu, W. (2016). Development of a double-antibody sandwich ELISA for rapid detection of *Bacillus cereus* in food. *Scientific Reports*, 6(1), 1-10.