KORUYUCULAR / ANTİOKSİDANLAR: HAYVANSAL ÜRETİMDE FONKSİYONEL KATKI MADDELERİ

BÖLÜM 9

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Ayşe Özge DEMİR [1]

1.GİRİŞ

Hayvansal üretim sistemlerinin sürdürülebilirliği, yalnızca hayvan sağlığı ve verimliliği ile değil; aynı zamanda yem kalitesinin korunması, ürün güvenliği ve raf ömrü gibi çok boyutlu hedeflerle doğrudan ilişkilidir. Yemlerin formülasyon, üretim, depolama ve tüketim aşamalarında karşılaşılan biyolojik ve kimyasal bozulmalar, üretim performansını düşürmekle kalmaz; aynı zamanda ekonomik kayıplara ve halk sağlığı risklerine yol açabilir (1). Bu çerçevede, yem katkı maddeleri arasında yer alan koruyucular ve antioksidanlar, yemlerin stabilitesini ve fonksiyonel değerini artırmak amacıyla geliştirilmiş iki temel bileşen grubudur.

1.1.Koruyucu ve antioksidan katkı maddelerinin tanımı

Koruyucular (preservatives), yemlerin mikrobiyolojik bozulmasını önlemek, raf ömrünü uzatmak ve küf, maya, bakteri gibi zararlı mikroorganizmaların gelişimini engellemek amacıyla kullanılan katkı maddeleridir. Özellikle sıcak ve nemli ortamlarda, mikotoksin üretiminin engellenmesinde propiyonik asit gibi koruyucuların etkinliği bilimsel olarak kanıtlanmıştır (2).

Antioksidanlar (antioxidants) ise, serbest radikal oluşumunu engelleyerek başta yağlar olmak üzere yem bileşenlerinin oksidatif bozulmasını önleyen maddelerdir. Bu katkılar, sadece yemin besin değerini korumakla kalmaz; aynı zamanda hayvanların bağışıklık sistemine destek sağlar ve et, süt ürünlerinde

[1] Dr. Öğr. Üyesi, Van Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi, Zootekni Bölümü, aodemir@yyu.edu.tr, ORCID iD: 0000-0001-7203-4734

HACCP	Gıda güvenliği risklerini kontrol altına almayı amaçlayan sistematik analiz sistemi.
DNA Mutagenezi	DNA dizisinin zarar görmesi ya da yapısının değişmesi süreci.
DOX-Yanıt İlişkisi	Biyolojik bir tepkinin, uygulanan madde miktarına bağlı olarak değişimini gösteren ilişki.
Akıllı Ambalaj	Oksijen göstergesi, tazelik algılayıcı gibi özellikler içeren, ürün koşullarını izleyen ambalaj teknolojisi.

KAYNAKLAR

1. Fellenberg, M. A., & Speisky, H. (2006). Antioxidants: Their effects on broiler oxidative stress and its meat oxidative stability. World's Poultry Science Journal, 62(1), 53–70. https://doi.org/10.1079/WPS200585
2. Binder, E. M., Tan, L. M., Chin, L. J., Handl, J., & Richard, J. (2007). Worldwide occurrence of mycotoxins in commodities, feeds and feed ingredients. Animal Feed Science and Technology, 137(3–4), 265–282. https://doi.org/10.1016/j.anifeedsci.2007.06.005
3. Surai, P. F. (2002). Natural antioxidants in avian nutrition and reproduction. Nottingham University Press.
4. Valko, M., et al. (2007). Free radicals and antioxidants in normal physiological functions and human disease. The International Journal of Biochemistry & Cell Biology, 39(1), 44–84. https://doi.org/10.1016/j.biocel.2006.07.001
5. Kralik, I., Kralik, G., & Grčević, M. (2018). Use of antioxidants in poultry production: Current status and future perspectives. World's Poultry Science Journal, 74(3), 523–538. https://doi.org/10.1017/S0043933918000479
6. Botsoglou, N. A., & Fletouris, D. J. (2001). Drug residues in foods: Pharmacology, food safety, and analysis. CRC Press.
7. Castro, A. G., et al. (2006). Effects of dietary antioxidants on immunocompetence and resistance to infectious diseases in animals. Animal Feed Science and Technology, 126(3), 215–234. https://doi.org/10.1016/j.anifeedsci.2005.08.016
8. Gessner, D. K., Ringseis, R., & Eder, K. (2017). Potential of plant polyphenols to combat oxidative stress and inflammatory responses in livestock – A review. Animal Feed Science and Technology, 233, 93–106. https://doi.org/10.1016/j.anifeedsci.2016.11.002
9. Zain, M. E. (2011). Impact of mycotoxins on humans and animals. Journal of Saudi Chemical Society, 15(2), 129–144. https://doi.org/10.1016/j.jscs.2010.06.006
10. Zhang, Z., Fan, X., Dai, Y., & Jia, J. (2022). Effects of antioxidants on physicochemical properties and lipid oxidation stability during storage. Frontiers in Nutrition, 9. https://doi.org/10.3389/fnut.2022.966697
11. Lykkesfeldt, J., & Svendsen, O. (2007). Oxidants and antioxidants in disease: Oxidative stress in farm animals. The Veterinary Journal, 173(3), 502–511. https://doi.org/10.1016/j.tvjl.2006.11.001
12. Estévez, M. (2015). Oxidative damage to poultry: From farm to fork. Poultry Science, 94(6), 1368–1378. https://doi.org/10.3382/ps/pev049
13. European Food Safety Authority (EFSA). (2023). Re-evaluation of synthetic antioxidants in animal feed: BHT, BHA, TBHQ and ethoxyquin. EFSA Journal, 21(5), e07730. https://doi.org/10.2903/j.efsa.2023.7730

14. Flieger J, Flieger W, Baj J, Maciejewski R. Antioxidants: Classification, Natural Sources, Activity/Capacity Measurements, and Usefulness for the Synthesis of Nanoparticles. Materials (Basel). 2021 Jul 25;14(15):4135. doi: 10.3390/ma14154135. PMID: 34361329; PMCID: PMC8347950.
15. Losada-Barreiro, S., Sezgin-Bayindir, Z., Paiva-Martins, F., & Bravo-Díaz, C. (2022). Biochemistry of Antioxidants: Mechanisms and Pharmaceutical Applications. Biomedicines, 10(12), 3051. https://doi.org/10.3390/biomedicines10123051
16. Gulcin İ. (2025). Antioxidants: a comprehensive review. Archives of toxicology, 99(5), 1893–1997. https://doi.org/10.1007/s00204-025-03997-2
17. Pecoraro, B.M., Leal, D.F., Frias-De-Diego, A. et al. The health benefits of selenium in food animals: a review. J Anim Sci Biotechnol 13, 58 (2022). https://doi.org/10.1186/s40104-022-00706-2
18. Berdahl, D. R., Nahas, R. I., & Barren, J. P. (2010). Synthetic and natural antioxidant additives in food stabilization: Current applications and future research. In E. A. Decker (Ed.), Oxidation in foods and beverages and antioxidant applications (Woodhead Publishing Series in Food Science, Technology and Nutrition, pp. 272–320). Woodhead Publishing. https://doi.org/10.1533/9780857090447.2.272
19. Chen, J., Huang, Z., Cao, X., et al., (2022). Plant-Derived Polyphenols as Nrf2 Activators to Counteract Oxidative Stress and Intestinal Toxicity Induced by Deoxynivalenol in Swine: An Emerging Research Direction. Antioxidants, 11(12), 2379. https://doi.org/10.3390/antiox11122379
20. Khan, M., Mushtaq, M., Usman, M., Rahman, M. A. U., & Quan, G. (2025). Oxidative stress-induced cytotoxicity and the role of dietary antioxidants in farm animals: A review. *Advances in Redox Research*. https://doi.org/10.1016/j.arres.2025.100138
21. Daré RG, Lautenschlager SOS. Nanoparticles with Antioxidant Activity. Antioxidants (Basel). 2025 Feb 15;14(2):221. doi: 10.3390/antiox14020221. PMID: 40002407; PMCID: PMC11852090.
22. Spears, J. W. (2000). Micronutrients and immune function in cattle. Proceedings of the Nutrition Society, 59(4), 587–594. https://doi.org/10.1017/S0029665100000839
23. Pandey, H., & Kumar, S. (2021). Butylated hydroxytoluene and Butylated hydroxyanisole induced cyto-genotoxicity in root cells of *Allium cepa* L. *Heliyon*, *7*(5), e07055. https://doi.org/10.1016/j.heliyon.2021.e07055
24. Hashemipour, H., Kermanshahi, H., Golian, A., & Veldkamp, T. (2013). Effect of thymol and carvacrol supplementation on performance, antioxidant enzyme activities, and immune response in broiler chickens. Poultry Science, 92(8), 2059–2069. https://doi.org/10.3382/ps.2012-02685
25. He, W., Tian, X., Zhou, Q. et al. Selenium nanoparticles ameliorate lumbar disc degeneration by restoring GPX1-mediated redox homeostasis and mitochondrial function of nucleus pulposus cells. J Nanobiotechnol 22, 634 (2024). https://doi.org/10.1186/s12951-024-02890-x
26. Yunitasari, F., Jayanegara, A., & Ulupi, N. (2023). Performance, egg quality, and immunity of laying hens due to natural carotenoid supplementation: A meta-analysis. *Food Science of Animal Resources, 43*(2), 282-295. https://doi.org/10.5851/kosfa.2023.e20
27. Xu, X., Liu, A., Hu, S., Ares, I., Martínez-Larrañaga, M.-R., Wang, X., Martínez, M., Anadón, A., & Martínez, M.-A. (2021). Synthetic phenolic antioxidants: Metabolism, hazards and mechanism of action. Food Chemistry, 353, 129488. https://doi.org/10.1016/j.foodchem.2021.129488
28. Halliwell, B. and Gutteridge, J.M.C. (2015) Free Radicals in Biology and Medicine. 5th Edition, Oxford University Press, New York. http://dx.doi.org/10.1093/acprof:oso/9780198717478.001.0001

29. Perron, N.R., Brumaghim, J.L. A Review of the Antioxidant Mechanisms of Polyphenol Compounds Related to Iron Binding. Cell Biochem Biophys 53, 75–100 (2009). https://doi.org/10.1007/s12013-009-9043-x
30. Ibiyo, L. M., Madu, C. T., & Eze, S. S. (2006). Effects of vitamin C supplementation on the growth of Heterobranchus longifilis fingerlings. *Archives of animal nutrition*, *60*(4), 325–332. https://doi.org/10.1080/17450390600785459
31. Surai, P. F., & Fisinin, V. I. (2015). Selenium in pig nutrition and reproduction: Boars and semen quality – A review. Asian-Australasian Journal of Animal Sciences, 28(5), 730–746. https://doi.org/10.5713/ajas.14.0593
32. Khan, I.T., Nadeem, M., Imran, M. et al. Antioxidant properties of Milk and dairy products: a comprehensive review of the current knowledge. Lipids Health Dis 18, 41 (2019). https://doi.org/10.1186/s12944-019-0969-8
33. Dansou DM, Zhang H, Yu Y, Wang H, Tang C, Zhao Q, Qin Y, Zhang J. Carotenoid enrichment in eggs: From biochemistry perspective. Anim Nutr. 2023 Jul 3;14:315-333. doi: 10.1016/j.aninu.2023.05.012. PMID: 37635928; PMCID: PMC10448277.
34. Ali, M., Imran, M., Nadeem, M. et al. Oxidative stability and Sensoric acceptability of functional fish meat product supplemented with plant–based polyphenolic optimal extracts. Lipids Health Dis 18, 35 (2019). https://doi.org/10.1186/s12944-019-0982-y
35. Hu X, Ma W, Zhang D, Tian Z, Yang Y, Huang Y, Hong Y. Application of Natural Antioxidants as Feed Additives in Aquaculture: A Review. Biology. 2025; 14(1):87. https://doi.org/10.3390/biology14010087
36. Serra V, Salvatori G, Pastorelli G. Dietary Polyphenol Supplementation in Food Producing Animals: Effects on the Quality of Derived Products. Animals (Basel). 2021 Feb 5;11(2):401. doi: 10.3390/ani11020401. PMID: 33562524; PMCID: PMC7914517.
37. Muhammad AI, Dalia AM, Loh TC, Akit H, Samsudin AA. Effect of organic and inorganic dietary selenium supplementation on gene expression in oviduct tissues and Selenoproteins gene expression in Lohman Brown-classic laying hens. BMC Vet Res. 2021 Aug 21;17(1):281. doi: 10.1186/s12917-021-02964-0. PMID: 34419016; PMCID: PMC8380377.
38. Fink-Gremmels, J. (2008). Mycotoxins in cattle feeds and carry-over to dairy milk: A review. Food Additives & Contaminants, 25(2), 172–180. https://doi.org/10.1080/02652030701823142
39. Muck, R. E., Nadeau, E. M. G., McAllister, T. A., Contreras-Govea, F. E., Santos, M. C., & Kung, L. (2018). Silage review: Recent advances and future uses of silage additives. Journal of Dairy Science, 101(5), 3980–4000. https://doi.org/10.3168/jds.2017-13839
40. Valero, M., & Giner, M. J. (2006). Effects of antimicrobial components of essential oils on growth of Bacillus cereus in vitro. Food Control, 17(5), 357–364. https://doi.org/10.1016/j.ijfoodmicro.2005.06.011
41. EFSA (European Food Safety Authority). (2011). Feed Additives Panel.Scientific Opinion on the safety and efficacy of propionic acid and its salts for all animal species. EFSA Journal, 9(7): 2216. https://doi.org/10.2903/j.efsa.2011.2216
42. Perera, W. N. U., & Ravindran, V. (2025). Role of feed additives in poultry nutrition: Historical, current and future perspectives. Animal Feed Science and Technology, 326, Article 116371. https://doi.org/10.1016/j.anifeedsci.2025.116371
43. Fauteux, M.-C., Gervais, R., Rico, D. E., (2016). Production, composition, and oxidative stability of milk highly enriched in polyunsaturated fatty acids from dairy cows fed alfalfa protein concentrate or supplemental vitamin E. Journal of Dairy Science, 99(6), 4411–4426. https://doi.org/10.3168/jds.2015-10722
44. Ponnampalam, E. N., Kiani, A., Santhiravel, S., Holman, B. W. B., Lauridsen, C., & Dunshea, F. R. (2022). The importance of dietary antioxidants on oxidative stress, meat and milk production, and their preservative aspects in farm animals: Antioxidant action, animal health, and

product quality—Invited review. Animals, 12(23), 3279. https://doi.org/10.3390/ani12233279
45. Alqhtani, A. H., Fatemi, S. A., Elliott, K. E. C., Branton, S. L., Evans, J. D., Leigh, S. A., Gerard, P. D., & Peebles, E. D. (2022). Effects of the In Ovo Vaccination of the ts-11 Strain of Mycoplasma gallisepticum in Layer Embryos and Posthatch Chicks. Animals, 12(9), 1120. https://doi.org/10.3390/ani12091120
46. International Feed Industry Federation (IFIF). (2013). *Comparison of approval process and risk-assessment procedures for feed ingredients: Canada, European Union, and United States*. IFIF Feed Additive Comparison Project.
47. European Commission (EC). (2003). Regulation (EC) No 1831/2003 on additives for use in animal nutrition. Official Journal of the European Union, L 268, 29–43.
48. European Food Safety Authority (EFSA). (2015). Scientific opinion on the risks for animal and human health related to the presence of ethoxyquin in feed. EFSA Journal, 13(11), 4272. https://doi.org/10.2903/j.efsa.2015.4272
49. EFSA FEEDAP Panel (EFSA Panel on Additives and Products or Substances used in Animal Feed). (2018). Scientific opinion on the safety and efficacy of butylated hydroxyanisole (BHA) as a feed additive for all animal species. EFSA Journal, 16(1), 5161. https://doi.org/10.2903/j.efsa.2018.5161
50. EFSA FEEDAP Panel (EFSA Panel on Additives and Products or Substances used in Animal Feed). (2022). Safety and efficacy of a feed additive consisting of butylated hydroxytoluene (BHT) for all animal species. EFSA Journal, 20(5), 7286. https://doi.org/10.2903/j.efsa.2022.7286
51. EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP Panel). (2017). Guidance on the assessment of the safety of feed additives for the target species. EFSA Journal, 15(10), 5022. https://doi.org/10.2903/j.efsa.2017.5022
52. European Commission (EC). (2009). Regulation (EC) No 767/2009 on the placing on the market and use of feed. Official Journal of the European Union, L 229, 1–28.
53. T.C. Tarım ve Orman Bakanlığı. (2013). Hayvan Beslemede Kullanılan Yem Katkı Maddeleri Hakkında Yönetmelik. Resmî Gazete, Sayı 28711.
54. Codex Alimentarius. (2003). Code of practice on good animal feeding (CAC/RCP 54-2004). FAO/WHO.
55. T.C. Ticaret Bakanlığı. (t.y.). Ürünlerin izlenebilirliği ve geri çağırma mekanizması – Sıkça sorulan sorular. Erişim tarihi: 25 Ağustos 2025, https://urunkurallari.ticaret.gov.tr/en/content/questions
56. T.C. Tarım ve Orman Bakanlığı. (2022). Yem katkı maddeleri kayıt ve izlenebilirlik sistemi kılavuzu.
57. Surai, P. F., & Fisinin, V. I. (2016). Antioxidant systems in animal body and poultry nutrition. World's Poultry Science Journal, 72(1), 27–48. https://doi.org/10.1017/S0043933915002896
58. Windisch, W., Schedle, K., Plitzner, C., & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. Journal of Animal Science, 86(14 Suppl), E140–E148. https://doi.org/10.2527/jas.2007-0459
59. FAO. (2019). Environmental performance of feed additives in livestock supply chains: Guidelines for assessment (Draft for public review). FAO. https://openknowledge.fao.org/handle/20.500.14283/ca6794en
60. Franz, C., Baser, K. H. C., & Windisch, W. (2010). Essential oils and aromatic plants in animal feeding – A European perspective: A review. Flavour and Fragrance Journal, 25(5), 327–340. https://doi.org/10.1002/ffj.1967
61. Ingale, O.S., Pravin, B.P., Pawase, P.A. et al. Enhancing bioactive stability and applications: microencapsulation in fruit and vegetable waste valorization. Discov Food 5, 148 (2025). https://doi.org/10.1007/s44187-025-00412-8

62. Subasi Gultekin , B., Saricaoglu, B., & Capanoglu, E. (2022). Microencapsulation methods for food antioxidants. In E. Capanoglu & V. Verardo (Eds.), *Plant antioxidants and health* (pp. 607–629). Springer. https://doi.org/10.1007/978-3-030-78160-6_25
63. Dodero, A., Escher, A., Bertucci, S., Castellano, M., & Lova, P. (2021). Intelligent packaging for realtime monitoring of foodquality: Current and future developments. Applied Sciences, 11(8), 3532. https://doi.org/10.3390/app11083532
64. European Union. (2018). Regulation (EU) 2018/848 on organic production and labeling of organic products. Official Journal of the European Union.
65. Alonso, M. E., González-Montaña, J. R., & Lomillos, J. M. (2020). Consumers' Concerns and Perceptions of Farm Animal Welfare. *Animals : an open access journal from MDPI*, *10*(3), 385. https://doi.org/10.3390/ani10030385