## ECOLOGY AND ENVIRONMENTAL TECHNOLOGY

DOI: 10.15587/2706-5448.2026.352998

### EVALUATION OF THE BEHAVIOR AND DISTRIBUTION OF MERCURY AND ASSOCIATED HEAVY METALS IN CONTAMINATED SOILS FROM AN ABANDONED MERCURY COMPLEX IN THE AZZABA REGION (NORTHEAST ALGERIA)

**pages 6–13**

***Rania Sbaghdi,*** *PhD Student, Department of Mining Engineering, Metallurgy and Materials, Laboratory of Mines, Metallurgy and Materials L3M, National Higher School of Technology and Engineering, Annaba, Algeria, ORCID: https://orcid.org/0009-0000-9920-3868, e-mail: r.sbaghdi@etu.ensti-annaba.dz*

***Abdellali Bouzenzana,*** *Doctor of Technical Sciences, Associate Professor, Department of Mines and Geo-technology, Laboratory of Mining, Echahid Echeikh Larbi Tebessi University, Tebessa, Algeria, ORCID: https://orcid.org/0000-0003-0440-9471*

***Hani Bouyahmed,*** *Biological Doctor, Leader of Biodiversity and Ecosystem Conservation Team, Laboratory of Ecotoxicology and Environmental Biomonitoring, Biotechnology Research Centre (CRBt), Constantine, Algeria, ORCID: https://orcid.org/0000-0003-0626-2581*

***Abdelfettah Gherib,*** *Biological Doctor, Director of Biotechnology and Environment Research Division, Laboratory of Ecotoxicology and Environmental Biomonitoring, Biotechnology Research Centre (CRBt), Constantine, Algeria, ORCID: https://orcid.org/0000-0002-7354-8873*

***Samir Chekchaki,*** *Doctor of Technical Sciences, Researcher, Laboratory of Ecotoxicology and Environmental Biomonitoring, Biotechnology Research Centre (CRBt), Constantine, Algeria, ORCID: https://orcid.org/0009-0009-4554-9287*

***Iness Braham,*** *PhD Student, Mining Department, Laboratory of Mineral Processing and Environment "LAVAMINE", University of Badji Mokhtar, Annaba, Algeria, ORCID: https://orcid.org/0009-0005-1006-7211*

This research is about the mercury and toxic metals pollution caused by the mining processes of cinnabar deposits at Ismail abandoned mercury complex in Algeria. This complex has caused many health and environmental problems in Azzaba area. The effect has continued to date with the presence of toxic elements even after almost 20 years since the site closed. Planning for remediation was never considered. However, this study aims to characterize the soil, by mercury and associated metals concentrations and physicochemical parameters. Also, to evaluate the behavior and distribution of toxic elements in samples based on the physicochemical parameters of the environment. The results show that all samples have a high level of toxic metals (Hg, Zn, Pb, As, Cr, Cu, and Sb) with averages in ppm, respectively (1526, 8421, 4372, 238, 134, 389, 124), these concentrations exceed standards, which increase the environmental risks. The statistical results show a correlation between pH–(Zn, Pb, Cr), Ec–(Pb, Cr and Cu), CEC–(Zn, Cu and As), OM–Zn and $CaCO_3$–(Zn, Pb, Cr, Cu and Sb) indicate that physicochemical parameters can affect the behavior and the mobility of metals. Except for Hg, which behaves in a particular way. In addition, according to ANOVA tests, Hg and As are evenly distributed throughout the study area. Unlike other metals, Pb, Cu and Sb to move to the surrounding soil or accumulate at a distance of 150 m while Zn and Cr accumulate in the upper part of the waste dump. This research investigates how toxic elements disperse or accumulate, make an assumption about their geochemical origin, and analyses their interactions with different soil characteristics. In addition, it contributes to the assessment of environmental risks and provides a relevant scientific support for planning appropriate decontamination and site restoration strategies.

**Keywords:** mercury district, toxic elements, physicochemical properties, soil, mobility, accumulation.

**References**

1. Kahangwa, C. A., Nahonyo, C. L., Sangu, G., Nassary, E. K. (2021). Assessing phytoremediation potentials of selected plant species in restoration of environments contaminated by heavy metals in gold mining areas of Tanzania. *Heliyon, 7 (9),* e07979. https://doi.org/10.1016/j.heliyon.2021.e07979
2. Karaca, O., Cameselle, C., Reddy, K. R. (2017). Acid pond sediment and mine tailings contaminated with metals: physicochemical characterization and electrokinetic remediation. *Environmental Earth Sciences, 76 (12).* https://doi.org/10.1007/s12665-017-6736-0
3. Fernández-Martínez, R., Corrochano, N., Álvarez-Quintana, J., Ordóñez, A., Álvarez, R., Rucandio, I. (2024). Assessment of the ecological risk and mobility of arsenic and heavy metals in soils and mine tailings from the Carmina mine site (Asturias, NW Spain). *Environmental Geochemistry and Health, 46 (3).* https://doi.org/10.1007/s10653-023-01848-6
4. Bauštein, M., Száková, J., Stefanović, L., Najmanová, J., Sysalová, J., Tlustoš, P. (2024). Assessment of Mercury Uptake by Plants in Former Cinnabar Mining Areas. *Minerals, 14 (12),* 1211. https://doi.org/10.3390/min14121211
5. Yan, J., Wang, C., Wang, Z., Yang, S., Li, P. (2019). Mercury concentration and speciation in mine wastes in Tongren mercury mining area, southwest China and environmental effects. *Applied Geochemistry, 106,* 112–119. https://doi.org/10.1016/j.apgeochem.2019.05.008
6. Kumar, V., Umesh, M., Shanmugam, M. K., Chakraborty, P., Duhan, L., Gummadi, S. N. et al. (2023). A Retrospection on Mercury Contamination, Bioaccumulation, and Toxicity in Diverse Environments: Current Insights and Future Prospects. *Sustainability, 15 (18),* 13292. https://doi.org/10.3390/su151813292
7. Seklaoui, M., Boutaleb, A., Benali, H., Alligui, F., Prochaska, W. (2016). Environmental assessment of mining industry solid pollution in the mercurial district of Azzaba, northeast Algeria. *Environmental Monitoring and Assessment, 188 (11).* https://doi.org/10.1007/s10661-016-5619-2
8. Benhamza, M., Hammar, Y. (2012). Contamination by mercury of groundwater of the North Numidian zone of Azzaba, North East Algeria. Effect of inorganic mercury contamination of population. *International Journal of Environment and Waste Management, 9 (3/4),* 347. https://doi.org/10.1504/ijewm.2012.046397
9. Benhamza, M. (2007). *Contribution de la géophysique à l'étude hydrogéologique de la zone mercurielle nord numidique(AZZABA)-Détermination du degré de pollution.* [Doctoral thesis]. Available at: https://biblio.univ-annaba.dz/wp-content/uploads/2014/06/BENHAMZA-Moussa.pdf
10. Benhamza, M., Kherici, N., Picard-Bonnaud, F., Nezzal, A. (2008). Qualité des eaux souterraines de la zone mercurielle Nord Numédique (AZZABA), Nord Est Algérie. Evaluation de la contamination de la population par le mercure inorganique. *Bulletin du Service Géologique de l'Algérie, 19 (2),* 135–149. Available at: https://asjp.cerist.dz/en/article/2758
11. Megueddem, M., Belmahi, H., Azzouz, M., Reggabi, M. (2004). Dosage du mercure sanguin chez des sujets professionnellement exposés. *Revue Française Des Laboratoires, 2004 (363),* 41–46. https://doi.org/10.1016/s0338-9898(04)80069-6
12. Seklaoui, M. (2018). *Etude environnementale de la pollution minière du district mercuriel d'Azzaba.* [Doctoral thesis]. Available at: https://theses-algerie.com/3175702025128580/these-de-doctorat/universite-des-sciences-et-de-la-technologie-houari-boumedien---alger/etude-environnementale-de-la-pollution-mini%C3%A8re-du-district-mercuriel-d-azzaba
13. Nannoni, A., Meloni, F., Benvenuti, M., Cabassi, J., Ciani, F., Costagliola, P. et al. (2022). Environmental impact of past Hg mining activities in the Monte Amiata district, Italy: A summary of recent studies. *AIMS Geosciences, 8 (4),* 525–551. https://doi.org/10.3934/geosci.2022029
14. Moussa, B., Djamel, R., Faouzi, B. M. (2015). Hydro Geochemistry and Balance between Minerals and Solutions in the Mercurial Zone of Azzaba, Northeast of Algeria. *Energy Procedia, 74,* 1133–1141. https://doi.org/10.1016/j.egypro.2015.07.754
15. Alligui, F., Boutaleb, A. (2010). Impact of Mercury Mine Activities on Water Resources at Azzaba-North-East of Algeria. *American Journal of Environmental Sciences, 6 (4),* 395–401. https://doi.org/10.3844/ajessp.2010.395.401

ISSN-L 2664-9969; E-ISSN 2706-5448

16. Alligui, F., Boutaleb, A. (2013). Origin and Speciation of Selected Trace Elements in Groundwater: A Case Study of Azzaba District in Northeast of Algeria. *Journal of Environment, 2 (6),* 134–139. Available at: https://www.researchgate.net/publication/299583965_Origin_and_Speciation_of_Selected_Trace_Elements_in_Groundwater_A_Case_Study_of_Azzaba_District_in_Northeast_of_Algeria
17. Walkley, A., Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science, 37 (1),* 29–38. https://doi.org/10.1097/00010694-193401000-00003
18. Lamas, F., Irigaray, C., Oteo, C., Chacón, J. (2005). Selection of the most appropriate method to determine the carbonate content for engineering purposes with particular regard to marls. *Engineering Geology, 81 (1),* 32–41. https://doi.org/10.1016/j.enggeo.2005.07.005
19. *Liming to Improve Soil quality in acid soil* (1999). U.S. Department of Agriculture, Natural Resources Conservation Service. Available at: https://www.nrcs.usda.gov/sites/default/files/2023-04/nrcs142p2_053252.pdf
20. Ech-Charef, A., Dekayir, A., Jordán, G., Rouai, M., Chabli, A., Qarbous, A. et al. (2023). Soil heavy metal contamination in the vicinity of the abandoned Zeïda mine in the Upper Moulouya Basin, Morocco. Implications for airborne dust pollution under semi-arid climatic conditions. *Journal of African Earth Sciences,* 198, 104812. https://doi.org/10.1016/j.jafrearsci.2022.104812
21. Badamasi, H., Dauda, A., Suleiman, A. K., Muhammad, S. E., Durumin-Iya, N. I., Abdullahi, H. U. (2024). Source Distribution and Ecological Risk Assessments of Heavy Metals from the Soils of Riruwai Mining Area, North-Western Nigeria. *Indonesian Journal of Environmental Management and Sustainability, 8 (1),* 25–33. https://doi.org/10.26554/ijems.2024.8.1.25-33
22. Petelka, J., Abraham, J., Bockreis, A., Deikumah, J. P., Zerbe, S. (2019). Soil Heavy Metal (loid) Pollution and Phytoremediation Potential of Native Plants on a Former Gold Mine in Ghana. *Water, Air, & Soil Pollution, 230 (11).* https://doi.org/10.1007/s11270-019-4317-4
23. *Standard operating procedure for soil pH determination* (2021). FAO, 23. Available at: https://openknowledge.fao.org/items/226f2913-07c3-4aaf-a94a-3147c2398aa5
24. Kahoul, M., Alioua, A., Nassima, D., Ayad, W. (2014). Comportement des micromycètes du sol vis-à-vis de la pollution mercurielle dans la région d'Azzaba (Algérie). *Journal of Materials and Environmental science. 5 (5),* 1470–1476. Available at: https://www.jmaterenvironsci.com/Document/vol5/vol5_N5/180-JMES-762-2014-Kahoul.pdf
25. Maphuhla, N. G., Lewu, F. B., Oyedeji, O. O. (2021). Accumulation of Heavy Metal Concentration and Physicochemical Parameters in Soil from Alice Landfill Site in Eastern Cape, South Africa. *Research Square.* https://doi.org/10.21203/rs.3.rs-621824/v1
26. Badamasi, H., Hassan, U. F., Adamu, H. M. (2022). Physico-chemical Properties and Heavy metal Contamination Levels of Soils from Riruwai Mining Area, North-western Nigeria. *Malaysian Journal of Applied Sciences, 7 (2),* 29–43. https://doi.org/10.37231/myjas.2022.7.2.324
27. He, G., Zhang, Z., Wu, X., Cui, M., Zhang, J., Huang, X. (2020). Adsorption of Heavy Metals on Soil Collected from Lixisol of Typical Karst Areas in the Presence of $CaCO_3$ and Soil Clay and Their Competition Behavior. *Sustainability, 12 (18),* 7315. https://doi.org/10.3390/su12187315
28. Yu, H., Li, C., Yan, J., Ma, Y., Zhou, X., Yu, W. et al. (2023). A review on adsorption characteristics and influencing mechanism of heavy metals in farmland soil. *RSC Advances, 13 (6),* 3505–3519. https://doi.org/10.1039/d2ra07095b
29. Gruszka, D., Szopka, K., Gruss, I., Złocka, M. (2025). Is the Soil in Allotment Gardens Healthy Enough? – Relation Between Organic Matter Content and Selected Heavy Metals. *Sustainability, 17 (16),* 7424. https://doi.org/10.3390/su17167424

DOI: 10.15587/2706-5448.2026.353109

## ASSESSMENT OF THE TECHNICAL CONDITION OF A TREATMENT FACILITY AT A CHEMICAL ENTERPRISE

**pages 14–19**

***Liudmyla Tsyhanenko,*** *PhD in Technical Sciences, Associate Professor, Department of Building Structures, Sumy National Agrarian University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0002-6628-3635*

***Oksana Shkromada,*** *Doctor of Veterinary Sciences, Professor, Polymerase Chain Diagnostics Research Laboratory, Sumy National Agrarian University, Sumy, Ukraine, e-mail: Oksana.Shkromada@snau.edu.ua, ORCID: https://orcid.org/0000-0003-1751-7009*

***Dmytro Volkov,*** *Senior Lecturer, Department of Building Structures, Sumy National Agrarian University, Sumy, Ukraine, ORCID: https://orcid.org/0009-0008-9263-4102*

***Oleksandr Chekan,*** *Doctor of Veterinary Sciences, Professor, Department of Obstetrics and Surgery, Polymerase Chain Diagnostics Research Laboratory, Sumy National Agrarian University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0002-5676-1947*

***Valerii Lutskovskyi,*** *PhD in Technical Sciences, Department of Building Structures, Sumy National Agrarian University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0003-0230-1029*

The object of research is a sewage well of a chemical enterprise. The chemical composition of the enterprise's wastewater, which is concentrated in the averaging unit, and the structural and elemental composition of concrete samples were determined. Upon completion of the experiment, proposals were made regarding the further operation of the chemical enterprise's treatment plant. It was found that the suspended solids content was higher in the first sample by 4.85%, and in the fifth – by 15.29%. The dry residue content was higher in the second sample by 20.18%, in the fourth – by 9.27%, and in the fifth – by 27.45%. The concentration of ammonium nitrogen is higher in the fourth experiment by 52.31%. The level of ammonium ions was higher in the fourth by 43.77%, nitrite ions in the second and third samples were higher by 16.67%, in the fourth by 383.33%, in the fifth by 983.33%. The increase in nitrate ions in the second sample was by 58.0%, in the third by 146.0%, in the fourth by 276.0%, in the fifth by 520.0%. APAR increased in the second water sample by 306.0%, in the third by 422.0%, in the fourth by 250.0%, in the fifth by 190.0%. The level of total iron is higher in the second group by 2288.89%, in the third – by 970.37%, in the fourth – by 1075.92%, in the fifth – by 1459.26%. The study by the X-ray fluorescence method showed that the CaO content was lower in the first sample by 3.27%, the second – by 2.27%, the third – by 3.01%; $Fe_2O_3$ is higher by 20.09%, by 22.77%, by 24.11%, $SiO_2$ by 10.83%, by 2.27%, 3.01%, $SO_2$ was by 4.50%, in the second and third – by 4.05%, $TiO_2$ by 0.68%, by 12.50%, by 14.19%. X-ray diffraction analysis showed the presence of a large amount of gypsum and quartz in the concrete.

The conducted research is distinguished by the fact that chemical corrosion of the concrete treatment plant under the influence of wastewater was established. The practical significance of the results obtained is that the destruction of the surface layer of concrete as a result of corrosion was established. Preventive measures are proposed to prevent corrosion of the treatment plant.

**Keywords:** chemical composition of wastewater, concrete corrosion, elemental composition, concrete structure.

**References**

1. Chen, X., Xu, Z., Yao, L., Ma, N. (2018). Processing Technology Selection for Municipal Sewage Treatment Based on a Multi-Objective Decision Model under Uncertainty. *International Journal of Environmental Research and Public Health, 15 (3),* 448. https://doi.org/10.3390/ijerph15030448
2. Brooks, B. W., Callahan, T., Stanley, J. K., Holodak, J., Stroski, K. M., Cox, A. H. et al. (2025). Identifying Priority Research Questions for Decentralized Wastewater. *Environmental Science & Technology, 60 (1),* 49–63. https://doi.org/10.1021/acs.est.5c02138
3. Xu, M., Zhang, K., Wang, Y., Zhang, B., Mao, K., Zhang, H. (2022). Health Risk Assessments and Microbial Community Analyses of Groundwater from a Heavy Metal-Contaminated Site in Hezhou City, Southwest China. *International Journal of Environmental Research and Public Health, 20 (1),* 604. https://doi.org/10.3390/ijerph20010604

4. Wang, J., Liu, A., Zheng, M., Li, Y., Shi, L., Cao, S. et al. (2025). Prevalence of Polyhalogenated Carbazole in an Anthropogenically Impacted Soil Groundwater System. *Environment & Health, 3 (6),* 636–647. https://doi.org/10.1021/envhealth.4c00263
5. Drane, K., Sheehan, M., Whelan, A., Ariel, E., Kinobe, R. (2024). The Role of Wastewater Treatment Plants in Dissemination of Antibiotic Resistance: Source, Measurement, Removal and Risk Assessment. *Antibiotics, 13 (7),* 668. https://doi.org/10.3390/antibiotics13070668
6. Wang, S., Yang, S., Quispe, E., Yang, H., Sanfiorenzo, C., Rogers, S. W. et al. (2021). Removal of Antibiotic Resistant Bacteria and Genes by UV-Assisted Electrochemical Oxidation on Degenerative $TiO_2$ Nanotube Arrays. *ACS ES&T Engineering, 1 (3),* 612–622. https://doi.org/10.1021/acsestengg.1c00011
7. Tsyhanenko, L., Volkov, D., Shkromada, O., Tsyhanenko, H., Lutskovskyi, V., Shpota, V. et al. (2025). Influence of vegetable fats on concrete of agricultural structures. *Technology Audit and Production Reserves, 2 (3 (82)),* 6–11. https://doi.org/10.15587/2706-5448.2025.325094
8. Shkromada, O., Tsyhanenko, L., Ivchenko, V., Tsyhanenko, H., Fotina, T., Berezovskyi, A. et al. (2025). The structure and properties features of concrete during exploitation under conditions of organic oil influence. *Journal of Chemistry and Technologies, 33 (2),* 449–457. https://doi.org/10.15421/jchemtech.v33i2.322601
9. Jiang, G., Zhou, M., Chiu, T. H., Sun, X., Keller, J., Bond, P. L. (2016). Wastewater-Enhanced Microbial Corrosion of Concrete Sewers. *Environmental Science & Technology, 50 (15),* 8084–8092. https://doi.org/10.1021/acs.est.6b02093
10. Gerengi, H., Kaya, E., Solomon, M. M., Snape, M., Koerdt, A. (2024). Advances in the Mitigation of Microbiologically Influenced Concrete Corrosion: A Snapshot. *Materials, 17 (23),* 5846. https://doi.org/10.3390/ma17235846
11. Aboulela, A., Peyre Lavigne, M., Buvignier, A., Fourré, M., Schiettekatte, M., Pons, T. et al. (2021). Laboratory Test to Evaluate the Resistance of Cementitious Materials to Biodeterioration in Sewer Network Conditions. *Materials, 14 (3),* 686. https://doi.org/10.3390/ma14030686
12. Fan, W., Zhuge, Y., Ma, X., Chow, C. W. K., Gorjian, N., Oh, J.-A. et al. (2020). Durability of Fibre-Reinforced Calcium Aluminate Cement (CAC)–Ground Granulated Blast Furnace Slag (GGBFS) Blended Mortar after Sulfuric Acid Attack. *Materials, 13 (17),* 3822. https://doi.org/10.3390/ma13173822
13. *DSTU EN ISO 5667-1:2022 Yakist vody. Vidbyrannia prob. Chastyna 1. Nastanovy shchodo rozroblennia prohram i metodiv vidbyrannia prob (EN ISO 5667-1:2022, IDT; ISO 5667-1:2020, IDT)* (20220). DP "UkrNDNTs". Available at: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=109217
14. Calvin, J. J., Kaufman, T. M., Sedlak, A. B., Crook, M. F., Alivisatos, A. P. (2021). Observation of ordered organic capping ligands on semiconducting quantum dots via powder X-ray diffraction. *Nature Communications, 12 (1).* https://doi.org/10.1038/s41467-021-22947-x
15. Steinegger, A., Wolfbeis, O. S., Borisov, S. M. (2020). Optical Sensing and Imaging of pH Values: Spectroscopies, Materials, and Applications. *Chemical Reviews, 120 (22),* 12357–12489. https://doi.org/10.1021/acs.chemrev.0c00451
16. Fisher, R. A. (1948). Questions and answers #14. *The American Statistician, 2 (5),* 30–31. https://doi.org/10.1080/00031305.1948.10483405
17. Kato, S., Kansha, Y. (2024). Comprehensive review of industrial wastewater treatment techniques. *Environmental Science and Pollution Research, 31 (39),* 51064–51097. https://doi.org/10.1007/s11356-024-34584-0
18. Belinawati, R. A. P., Soesilo, T. E. B., Asteria, D., Harmain, R. (2018). Sustainability: Citarum River, government role on the face of SDGs (water and sanitation). *E3S Web of Conferences, 52,* 00038. https://doi.org/10.1051/e3sconf/20185200038
19. Pratiwi, D., Sumiarsa, D., Oktavia, D., Sunardi, S. (2023). Water Quality Influences Self-Purification in the Cihawuk and Majalaya Segments Upstream of the Citarum River, West Java, Indonesia. *Water, 15 (16),* 2998. https://doi.org/10.3390/w15162998
20. Słomka-Słupik, B., Podwórny, J., Grynkiewicz-Bylina, B., Salamak, M., Bartoszek, B., Drzyzga, W. et al. (2021). Concrete Examination of 100-Year-Old Bridge Structure above the Kłodnica River Flowing through the Agglomeration of Upper Silesia in Gliwice: A Case Study. *Materials, 14 (4),* 981. https://doi.org/10.3390/ma14040981
21. Luo, Z., Yu, H., Ma, H., Tan, Y., Wu, C., Sun, J. et al. (2025). Corrosion Products and Microstructural Evolution of Ordinary Portland Cement and High-Performance Concrete After Eight Years of Field Exposure in Qarhan Salt Lake. *Materials, 18 (8),* 1769. https://doi.org/10.3390/ma18081769
22. Zhang, C., Li, J., Yu, M., Lu, Y., Liu, S. (2024). Mechanism and Performance Control Methods of Sulfate Attack on Concrete: A Review. *Materials, 17 (19),* 4836. https://doi.org/10.3390/ma17194836
23. Sun, D., Huang, C., Cao, Z., Wu, K., Zhang, L. (2021). Reliability assessment of concrete under external sulfate attack. *Case Studies in Construction Materials, 15,* e00690. https://doi.org/10.1016/j.cscm.2021.e00690
24. Sopov, V., Danchenko, J., Latorez, E. (2019). Assess the Effectiveness of protective Concrete coatings of microbiological sulfuric acid Aggression. *E3S Web of Conferences, 97,* 02022. https://doi.org/10.1051/e3sconf/20199702022
25. Merachtsaki, D., Tsardaka, E.-C., Tsampali, E., Simeonidis, K., Anastasiou, E., Yiannoulakis, H. et al. (2020). Study of Corrosion Protection of Concrete in Sewage Systems with Magnesium Hydroxide Coatings. *4th EWaS International Conference: Valuing the Water, Carbon, Ecological Footprints of Human Activities,* 27. https://doi.org/10.3390/environsciproc2020002027
26. Jiang, G., Li, X., Song, Y.; Jiang, G. (Ed.) (2023). Concrete Sewer Systems and Wastewater Processes Related to Concrete Corrosion. *Microbiologically Influenced Corrosion of Concrete Sewers.* Cham: Springer, 3–20. https://doi.org/10.1007/978-3-031-29941-4_1
27. Gutarowska, B., Kotynia, R., Bieliński, D., Anyszka, R., Wręczycki, J., Piotrowska, M. et al. (2019). New Sulfur Organic Polymer-Concrete Composites Containing Waste Materials: Mechanical Characteristics and Resistance to Biocorrosion. *Materials, 12 (16),* 2602. https://doi.org/10.3390/ma12162602

# FOOD PRODUCTION TECHNOLOGY

DOI: 10.15587/2706-5448.2026.352898

## JUSTIFICATION OF THE PRELIMINARY ENZYMATIC TREATMENT OF BERRIES OF DOGWOOD, BLACK ELDERBERRY, HAWTHORN, BARBERRY AND RASPBERRY, GROWN IN THE TERRITORY OF THE REPUBLIC OF AZERBAIJAN

**pages 20–28**

***Sevinj Maharramova,*** *PhD in Biology, Associate Professor, Department of Engineering and Applied Sciences (UNEC), Azerbaijan State University of Economics, Baku, Azerbaijan, ORCID: https://orcid.org/0000-0002-1599-7013*

***Ilhama Kazimova,*** *PhD in Engineering, Associate Professor, Department of Engineering and Applied Sciences, Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan, ORCID: https://orcid.org/0000-0003-3857-9575*

***Mikail Maharramov,*** *Doctor of Technical Sciences, Professor, Department of Technology and Technical Disciplines, Lankaran State University, Lankaran, Azerbaijan, e-mail: mikailbyst@mail.ru, ORCID: https://orcid.org/0000-0002-4688-5823*

The research shows the results of the effect of preliminary enzymatic treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberry on juice yield and extraction of valuable chemical compounds and nutrients into juice. The objects of the research were the technology for enzymatic extraction of dogwood berries, black elderberries, hawthorn berries, barberries, and raspberries. Enzyme preparations with pectolytic and gluconolytic activity were also investigated. The enzymes included Pectinex BE XXL, Pectinex Yieldash Extra, Amylase AG 300 L, and Fructozym P. Additional preparations used in the research were Rapidaza CR, Bryuzaym BGX, Laminex Super, Selloviridin Q20X, Sellokyuks-A Extra, and Enzerzim XT. The experiment

ISSN-L 2664-9969; E-ISSN 2706-5448

used modern photometric, thermogravimetric, refractometric, potentiometric, chromatographic and other methods of analysis. It was established that the use of a composition of enzyme preparations with pectolytic and glucanolytic action Pectinex BE XXL, Amylase AG 300 L, Rapidaza CR, Sellokyuks-A contributes to an increase in the yield of unclarified juices by an average of 6.8–9.4% compared to the control samples. In this case, the most effective are the use of Fructosym P, Pectinex BE XXL and Amylase AG300L, and when using multienzyme complexes, MFK-I and MFK-II turned out to be more effective, each consisting of a mixture of two enzymes, the juice yield increased by an average of 11.0–14.4% or 1.19–1.29 times compared to the control. The use of the enzyme preparation composition allows to increase the yield of valuable natural components and functional food ingredients in the juice – total sugars by 1.05–1.23 times, organic acids by 1.04–1.24 times, pectin substances by 1.06–1.31 times, ash substances by 1.19–1.33 times, vitamin C by 1.18–1.38 times. The extraction of natural antioxidants and preservatives increases the nutritional value of the juice and improves its technological properties.

**Keywords:** berries, enzyme preparations, multi-enzyme composition, juice yield, chemical composition, carbohydrates, pectin.

**References**

1. Magerramov, M. A. (2020). *Nauchnye osnovy proizvodstva, teplo i elektrofizicheskie svoistva plodoovoshchnykh sokov.* Liankaran: LGU, 321.
2. Rajendran, P., Nandakumar, N., Rengarajan, T., Palaniswami, R., Gnanadhas, E. N., Lakshminarasaiah, U. et al. (2014). Antioxidants and human diseases. *Clinica Chimica Acta, 436,* 332–347. https://doi.org/10.1016/j.cca.2014.06.004
3. Loi, M., Paciolla, C. (2021). Plant Antioxidants for Food Safety and Quality: Exploring New Trends of Research. *Antioxidants, 10 (6),* 972. https://doi.org/10.3390/antiox10060972
4. Olas, B. (2018). Berry Phenolic Antioxidants – Implications for Human Health? *Frontiers in Pharmacology, 9.* https://doi.org/10.3389/fphar.2018.00078
5. Lourenço, S. C., Moldão-Martins, M., Alves, V. D. (2019). Antioxidants of Natural Plant Origins: From Sources to Food Industry Applications. *Molecules, 24 (22),* 4132. https://doi.org/10.3390/molecules24224132
6. Novruzov, E. N., Mustafaeva, L. A., Zeynalli, A. Z. (2019). Comparative study of the chemical composition and antioxidant properties of extracts of various cornel (*Cornus mas L.*) organs. *Plant & Fungal Research, 2 (2),* 41–48. https://doi.org/10.29228/plantfungalres.23
7. Məhərrəmov, M. Ə., Məhərrəmova, S. İ., Kazımova, İ. H. (2019). *Xammal və qida məhsullarının təhlükəsizliyi.* Bakı: "İqtisad Universiteti" Nəşriyyatı, 270. Available at: https://mek.org.az/e-kitabxana/kitab.php?id=22902
8. Sharma, H. P., Patel, H., Sugandha. (2016). Enzymatic added extraction and clarification of fruit juices – A review. *Critical Reviews in Food Science and Nutrition, 57 (6),* 1215–1227. https://doi.org/10.1080/10408398.2014.977434
9. Məhərrəmov, M. Ə. (2017). *Qida məhsulları texnologiyasının nəzəri əsasları.* Bakı: "İqtisad Universiteti" Nəşriyyatı, 384. Available at: https://www.preslib.az/az/book/vyhYX3HmJrLlGIk
10. Aït-Kaddour, A., Hassoun, A., Tarchi, I., Loudiyi, M., Boukria, O., Cahyana, Y. et al. (2024). Transforming plant-based waste and by-products into valuable products using various "Food Industry 4.0" enabling technologies: A literature review. *Science of The Total Environment, 955,* 176872. https://doi.org/10.1016/j.scitotenv.2024.176872
11. Koponen, J. M., Buchert, J., Poutanen, K. S., Törrönen, A. R. (2007). Effect of pectinolytic juice production on the extractability and fate of bilberry and black currant anthocyanins. *European Food Research and Technology, 227 (2),* 485–494. https://doi.org/10.1007/s00217-007-0745-2
12. Liu, S., Chang, X., Liu, X., Shen, Z. (2016). Effects of pretreatments on anthocyanin composition, phenolics contents and antioxidant capacities during fermentation of hawthorn (*Crataegus pinnatifida*) drink. *Food Chemistry, 212,* 87–95. https://doi.org/10.1016/j.foodchem.2016.05.146
13. Marsol-Vall, A., Kelanne, N., Nuutinen, A., Yang, B., Laaksonen, O. (2021). Influence of enzymatic treatment on the chemical composition of lingonberry (Vaccinium vitis-idaea) juice. *Food Chemistry, 339,* 128052. https://doi.org/10.1016/j.foodchem.2020.128052
14. Kruszewski, B., Boselli, E. (2024). Blackcurrant Pomace as a Rich Source of Anthocyanins: Ultrasound-Assisted Extraction under Different Parameters. *Applied Sciences, 14 (2),* 821. https://doi.org/10.3390/app14020821
15. Bamba, B. S. B., Shi, J., Tranchant, C. C., Xue, S. J., Forney, C. F., Lim, L.-T. (2018). Influence of Extraction Conditions on Ultrasound-Assisted Recovery of Bioactive Phenolics from Blueberry Pomace and Their Antioxidant Activity. *Molecules, 23 (7),* 1685. https://doi.org/10.3390/molecules23071685
16. Li, X., Zhu, F., Zeng, Z. (2021). Effects of different extraction methods on antioxidant properties of blueberry anthocyanins. *Open Chemistry, 19 (1),* 138–148. https://doi.org/10.1515/chem-2020-0052
17. Maharramova, S. (2023). Changes in the chemical composition of extracts of wild berries growing in the Republic of Azerbaijan during enzimatic pretreatment of their pulp. *Ukrainian Food Journal, 12,* 542–555. https://doi.org/10.24263/2304-974x-2023-12-4-5
18. Magerramova, S. I. (2022). Vliianie predvaritelnoi fermentativnoi obrabotki na biologicheski aktivnye soedienie i antioksidantnye svoistva nekotorykh iagod. *Technical and Agrarian sciences, 1,* 46–51. Available at: https://lsu.edu.az/new/imgg/aqrar-2023/tex_aqr_1_2022.pdf
19. Qədimova, N. S. (2025). *Bitki mənşəli bioloji fəal əlavələrin tətbiqi ilə içkilərin texnologiyasının təkmilləşdirilməsi.* [Extended abstract of Doctoral dissertation]. Available at: https://adau.edu.az/images/files/2025-05/1748261455_avtoreferat-az-qdimova-natvan-a5-3.pdf
20. Qasımov, H. (2017). Naxçıvan Muxtar Respublikası florasının alkoqollu içki və sirkə alınan bitkiləri. *Elmi Əsərlər, 3 (84),* 33–40. Available at: https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/84%20tebiet%202017.pdf
21. İbrahimov, Ə., İbrahimov, Ə., Qurbanov, Ə. (2017). Naxçıvan Muxtar Respublikasının bəzi perspektivli yabanı qida meyvə bitkilərinin xalq təsərrüfatı əhəmiyyəti. *Elmi Əsərlər, 7,* 33–39. Available at: https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/88%20t%E2%95%94%D0%A9bi%E2%95%94%D0%A9t%202017.pdf
22. Ionsecu, A.-D., Voicu, G., Ferdes, M., Ipate, G., Constantin, G.-A., Stefan, E.-M., Begea, M. (2024). *Effect of Grinding and Successive Sieving on Active Biological Compounds in the Obtained Fractions of Blackthorn Berries.* https://doi.org/10.20944/preprints202406.1934.v1
23. Bastos, K. V. L. da S., de Souza, A. B., Tomé, A. C., Souza, F. de M. (2025). New Strategies for the Extraction of Antioxidants from Fruits and Their By-Products: A Systematic Review. *Plants, 14 (5),* 755. https://doi.org/10.3390/plants14050755
24. Nicolescu, A., Babotă, M., Zhang, L., Bunea, C. I., Gavrilaș, L., Vodnar, D. C. et al. (2022). Optimized Ultrasound-Assisted Enzymatic Extraction of Phenolic Compounds from Rosa canina L. Pseudo-Fruits (Rosehip) and Their Biological Activity. *Antioxidants, 11 (6),* 1123. https://doi.org/10.3390/antiox11061123
25. Al-Khayri, J. M., Rashmi, R., Toppo, V., Chole, P. B., Banadka, A., Sudheer, W. N. et al. (2023). Plant Secondary Metabolites: The Weapons for Biotic Stress Management. *Metabolites, 13 (6),* 716. https://doi.org/10.3390/metabo13060716
26. Cavdar Dincturk, H., Can Karaca, A., Capanoglu, E. (2025). Development of novel processing technologies for sustainable production of berries. *Berry Fruits,* 325–341. https://doi.org/10.1016/b978-0-443-16011-0.00009-2

DOI: 10.15587/2706-5448.2026.353015

## ESTABLISHING THE PATTERNS OF INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THE BIOCHEMICAL INDICATORS OF GRAPE MUST AND THE WINE PRODUCED FROM IT

**pages 29–37**

***Vusala Shukurova,*** *Head of Department of Laboratory of Biochemical Research and Quality Control, Scientific-Research Institute of Viticulture and Winemaking, Mehdiabad, Azerbaijan, ORCID: https://orcid.org/0000-0003-2457-815X*

***Movlud Huseynov,*** *PhD of Engineering, Associate Professor, Department of Engineering and Applied Sciences, Azerbaijan State University of Economics, UNEC, Baku, Azerbaijan, ORCID: https://orcid.org/0000-0002-8774-3661*

***Vugar Salimov,*** *Doctor of Agrarian Sciences, Associate Professor, Director, Scientific-Research Institute of Viticulture and Winemaking, Mehdiabad, Azerbaijan, ORCID: https://orcid.org/0000-0002-5041-6958*

***Afet Gasimova,*** *PhD of Engineering, Associate Professor, Department of Food Engineering and Winemaking, Azerbaijan Technological University, Ganja, Azerbaijan, e-mail: a.qasimova@atu.edu.az, ORCID: https://orcid.org/0000-0002-9814-4488*

The object of research is grape must and wines made from white and red grape varieties grown in the conditions of the Absheron and Gabala regions. The article provides a comparative analysis of the biochemical indicators of must and wine samples made from grape varieties grown in the ecological and geographical conditions of the Absheron and Gabala regions of Azerbaijan. Grapes of some white (Muscat white, Viognier, Chardonnay, Semillon, Riesling, Bayan Shirey, Rkatsiteli) and red (Aleatico, Shiraz, Merlot, Madrasa) varieties were used as the research material. In order to determine the direction of use and technological suitability of the harvest of the studied grape varieties, the biochemical indicators of must were studied, various wine samples were prepared and their physicochemical analysis was carried out. It was found that the biochemical composition of the must and the physicochemical indicators of wine samples vary depending on the soil and climatic conditions of the place where the grape variety is grown. It turned out that the juice density of grape varieties grown in the Gabala district is 1.09122–1.11207 g/L, and the juice density of grape varieties grown in the Absheron district is higher and is 0.90010–1.90024 g/L. Grape varieties grown in the Gabala district are characterized by a higher content of tartaric acid. The highest content of tartaric acid was noted in the Semillon variety. In grape varieties grown in the Gabala district, the malic acid content varies in the range of 0.3–3.2 g/L, and in varieties grown in the Absheron district, within 0.2–1.2 g/L. The amount of polyphenols in grapes grown in the Gabala district was higher than the similar indicator for the Absheron district. The obtained results can be used in the winemaking industry, which will allow producers to more accurately select raw materials for the production of a specific type of wine, and can also be useful for winemakers in other regions with similar soil and climatic conditions and the assortment of regionalized varieties.

**Keywords:** white and red grape varieties, must, wine, biochemical indicators, phenolic compounds.

**References**

1. Schultz, H. R., Jones, G. V. (2010). Climate Induced Historic and Future Changes in Viticulture. *Journal of Wine Research, 21 (2-3),* 137–145. https://doi.org/10.1080/09571264.2010.530098
2. Saliba, A., Ovington, Moran, C. (2013). Consumer demand for low-alcohol wine in an Australian sample. *International Journal of Wine Research, 5,* 1–8. https://doi.org/10.2147/ijwr.s41448
3. Bagirzade, A., Omarov, Y., Aliyeva, J., Gurbanova, S., Omarova, E., Gasimova, A., Nabiyev, A. (2024). Establishing a pattern of change in the quality indicators of Tokaj-type wine materials prepared by different variants. *Eastern-European Journal of Enterprise Technologies, 5 (11 (131)),* 92–108. https://doi.org/10.15587/1729-4061.2024.312056
4. Kunter, B., Canturk, S., Keskin, N. (2013). Üzüm Tanesinin Histokimyasal Yapısı. *Iğdır University Journal of the Institute of Science and Technology, 3 (2),* 17–24. Available at: https://dergipark.org.tr/en/download/article-file/410479
5. Tüfekci, H. B., Fenercioğlu, H. (2010). Türkiye'de üretilen bazı ticari meyve sularının kimyasal özellikler açısından gıda mevzuatına uygunluğu. *Akademik Gıda, 8 (2),* 11–17. Available at: https://dergipark.org.tr/en/download/article-file/1189416
6. Asadullayev, R. A., Salimov, V. S., Huseynov, M. A. (2024). Grapes with fungal infection during long-term storage. *SABRAO Journal of Breeding and Genetics, 56 (5),* 2026–2032. https://doi.org/10.54910/sabrao2024.56.5.25
7. Salimov, V. S., Huseynov, M. A. (2025). Polymorphism features in grape (*Vitis vinifera L.*) variety Bayanshira populations. *SABRAO Journal of Breeding and Genetics, 57 (2),* 516–528. https://doi.org/10.54910/sabrao2025.57.2.11
8. Salimov, V. S., Huseynov, M. A., Huseynova, A. S. (2025). Phenotypic variability in the vegetative generation of grape (*V. vinifera L.*) protoclones and selection with stable signs. *SABRAO Journal of Breeding and Genetics, 57 (3),* 999–1008. https://doi.org/10.54910/sabrao2025.57.3.12
9. Levchenko, S., Volynkin, V., Likhovskoi, V., Vasylyk, I., Ostroukhova, E., Vasylyk, A. et al. (2021). The profile of the phenolic components of grape cultivars of a complex genetic structure. *Acta Horticulturae, 1307,* 391–398. https://doi.org/10.17660/actahortic.2021.1307.59
10. Fətəliyev, H. K. (2011). *Şərabın texnologiyası.* Bakı: Elm, 596. Available at: http://anl.az/el/264414.pdf
11. Səlimov, V. S. (2019). *Üzümün ampeloqrafik skrininqi.* Bakı: Müəllim, 319. Available at: https://www.researchgate.net/publication/377701284_Uzumun_ampeloqrafiq_skrininqi
12. Bagirzadeh, A., Omarov, Y., Haciyeva, A., Gurbanova, S., Gasimova, A., Ismayilov, M., Nabiyev, A. (2023). Improvement of the production technology of tokay wines based on the revealed effect of enzyme activity on the quality of grape variety. *Eastern-European Journal of Enterprise Technologies, 2 (11 (122)),* 49–62. https://doi.org/10.15587/1729-4061.2023.276251
13. Şəfizadə, C. Ə. (2017). Qırmızı üzüm sortlarının mexaniki-kimyəvi tərkibinin öyrənilməsi. *Azərbaycan Aqrar Elmi, 3,* 214–215.
14. Cabaroğlu, T. (2023). *Üzümün işlenmesi ve qida sanayinde değerlendirilmesi.* Tekirdağ: Bağcılık vizyon, 44–61. Available at: https://arastirma.tarimorman.gov.tr/bagcilik/Belgeler/VIZYON_2023_CALISTAY.pdf
15. Zhao, B., Hall, C. A. (2008). Composition and antioxidant activity of raisin extracts obtained from various solvents. *Food Chemistry, 108 (2),* 511–518. https://doi.org/10.1016/j.foodchem.2007.11.003
16. Ribéreau-Gayon, P., Glories, Y., Maujean, A., Dubourdieu, D. (2006). *Handbook of enology: The chemistry of wine and stabilization and treatments.* John Wiley and Sons, Ltd. https://doi.org/10.1002/0470010398
17. Boulton, R. B., Singleton, V. L., Bisson, L. F., Kunkee, R. E. (1996). *Principles and practices of winemaking.* New York: Chapman and Hall. https://doi.org/10.1007/978-1-4615-1781-8
18. Vanjare, M., Sahane, V., Gulve, Y., Chaudhari Y. (2022). Comparative analysis of different grapes verities for red wine production. *International Journal of Biological Macromolecules, 4 (1),* 45–53. Available at: https://kjscollege.com/_0_KJSCollege_Data_Center/_01_Image_Files/_01_NAAC_Files/KJSCollege_3933038b-42f9-4636-bfa5-a6c8ecbccb4c_55V38TXF.pdf
19. González-Neves, G., Franco, J., Barreiro, L., Gil, G., Moutounet, M., Carbonneau, A. (2006). Varietal differentiation of Tannat, Cabernet-Sauvignon and Merlot grapes and wines according to their anthocyanic composition. *European Food Research and Technology, 225 (1),* 111–117. https://doi.org/10.1007/s00217-006-0388-8
20. Compendium of international methods of wine and must analysis. *OIV.* Available at: https://www.oiv.int/standards/compendium-of-international-methods-of-wine-and-must-analysis
21. Mateus, N., Machado, J. M., de Freitas, V. (2002). Development changes of anthocyanins in Vitis vinifera grapes grown in the Douro Valley and concentration in respective wines. *Journal of the Science of Food and Agriculture, 82 (14),* 1689–1695. https://doi.org/10.1002/jsfa.1237
22. Huseynov, M. A., Shukurov, A. S., Salimov, V. S., Adilov, A. A., Mirzoev, G. S., Sadigov, R. A. (2025). Quality characteristics of technical grape (*Vitis vinifera L.*) cultivars grown under environmental conditions of the mountains and sea. *SABRAO Journal of Breeding and Genetics, 57 (6),* 2564–2573. https://doi.org/10.54910/sabrao2025.57.6.29

ISSN-L 2664-9969; E-ISSN 2706-5448


**23.** Səlimov, V. S., Hüseynov, M. Ə., Şükürov, A. S. (2022). *Üzüm: aqrotexnikası, aqrokimyası və inteqrir mübarizə tədbirləri.* Bakı: "Sapfir-15", 784. Available at: https://anl.az/el/kitab2022/08/cd/Azf-325327.pdf

**24.** Yıldırım, D., Özonur, A., Darıcı, M., Cabaroğlu, T. (2023) Yörenin (şarköy/tekirdağ-urla/izmir) cabernet sauvignon üzüm ve şaraplarının genel bileşimi ve fenolik bileşikleri üzerine etkisi. *Özel Sayı, 1,* 276–285. Available at: https://dergipark.org.tr/en/pub/bahce/article/1257818

**25.** Şan, F. H., Cabaroğlu, T. (2016). Ülkemizde üretilen önemli yerli ve yabancı şaraplık üzüm çeşitlerinin şeker ve organik asit içeriklerinin belirlenmesi. *Ç.Ü Fen ve Mühendislik Bilimleri Dergisi Yıl 2018 Cilt, 35-6,* 65–72. Available at: https://fbe.cu.edu.tr/storage/fbeyedek/makaleler/2017/%C3%9CLKEM%C4%B0ZDE%20%C3%9CRET%C4%B0LEN.pdf

**26.** Şimşek, S. (2008). Şarap üretimi ve kalite kontrolü. *Çanakkale Onsekiz Mart Üniversitesi Mühendislik-Mimarlık, Yayın No:003.*

**27.** Candar, S., Alço, T., Uysal, T., Uysal Seçkin, G., Güngör, T. A., Eryılmaz, İ. et al. (2023). Oenological properties and terroir characteristics of an autochthonous grape cultivar: Ada Karası (*Vitis vinifera L.*). *European Food Research and Technology, 249 (10),* 2595–2610. https://doi.org/10.1007/s00217-023-04317-7

**28.** Proestos, C., Bakogiannis, A., Psarianos, C., Koutinas, A. A., Kanellaki, M., Komaitis, M. (2005). High performance liquid chromatography analysis of phenolic substances in Greek wines. *Food Control, 16,* 319–323. https://doi.org/10.1016/s0956-7135(04)00076-3

**29.** Ali, K., Maltese, F., Choi, Y. H., Verpoorte, R. (2009). Metabolic constituents of grapevine and grape-derived products. *Phytochemistry Reviews, 9 (3),* 357–378. https://doi.org/10.1007/s11101-009-9158-0

**30.** Pereira, G. E., Gaudillere, J.-P., Leeuwen, C. van, Hilbert, G., Maucourt, M., Deborde, C. et al. (2006). 1H NMR metabolite fingerprints of grape berry: Comparison of vintage and soil effects in Bordeaux grapevine growing areas. *Analytica Chimica Acta, 563 (1-2),* 346–352. https://doi.org/10.1016/j.aca.2005.11.007

**31.** Li, Z., Pan, Q., Jin, Z., Mu, L., Duan, C. (2011). Comparison on phenolic compounds in Vitis vinifera cv. Cabernet Sauvignon wines from five wine-growing regions in China. *Food Chemistry, 125 (1),* 77–83. https://doi.org/10.1016/j.foodchem.2010.08.039

**32.** Rastija, V., Srečnik, G., Medić-Šarić, M. (2009). Polyphenolic composition of Croatian wines with different geographical origins. *Food Chemistry, 115 (1),* 54–60. https://doi.org/10.1016/j.foodchem.2008.11.071

**33.** Tangolar, S., Özdemir, G., Bilir, H., Sabır, A. (2005). Bazı şaraplık çeşitlerinin Pozantı/Adana ekolojik koşullarında fenolojileri ile salkım ve tane özelliklerinin saptanması. *Türkiye 6. Bağcılık Semp.* Tekirdağ. Available at: https://www.researchgate.net/publication/291697798_Bazi_Saraplik_Uzum_Cesitlerinin_PozantiAdana_Ekolojik_Kosullarinda_Fenolojileri_ile_Salkim_ve_Tane_Ozelliklerinin_Saptanmasi

**34.** Cheng, G., Fa, J.-Q., Xi, Z.-M., Zhang, Z.-W. (2015). Research on the quality of the wine grapes in corridor area of China. *Food Science and Technology (Campinas), 35 (1),* 38–44. https://doi.org/10.1590/1678-457x.6455

**35.** Bora, F. D., Pop, T. I., Bunea, C. I., Urcan, D. E., Babeş, A., Mihaly-Cozmuta, L. et al. (2014). Influence of Ecoclimatic and Ecopedological Conditions on Quality of White Wine Grape Varieties from North-West of Romania. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. *Horticulture, 71 (2),* 218–225. https://doi.org/10.15835/buasvmcn-hort:10545

**36.** Kaya, Z. (2017). Şarap üretimi ve kalite. *Ambiyans Şarap Evi, Aydın Gastronomy, 1 (2),* 17–30. Available at: https://dergipark.org.tr/en/download/article-file/498270

**37.** Altuğ, T., Elmacı, Y. (2005). *Gıdalarda duyusal değerlendirme.* Ege Üniversitesi. İzmir, 92. Available at: https://akademik.adu.edu.tr/myo/cine/webfolders/File/ders%20notlari/gidalarda%20duyusal%20analizler.pdf

**38.** *Türk gıda kodeksi şarap tebliği* (2009). Resmi Gazete 4.2.2009, Sayı:27131, Tebliğ No:2008/67. Available at: https://www.tarimorman.gov.tr/TADAB/Belgeler/Alkoll%C3%BC%20%C4%B0%C3%A7kiler/%C4%B0lgili%20Mevzuat%20D%C3%BCzenlemeleri/sarap_teblig.pdf

**39.** Waterhouse, A. L., Sacks, G. L., Jeffery, D. W. (2016). *Understanding wine chemistry.* Chichester: John Wiley & Sons Inc., 480. https://doi.org/10.1002/9781118730720

**40.** Fataliyev, H., Malikov, A., Lazgiyev, Y., Haydarov, E., Agayeva, S., Baloghlanova, K. et al. (2023). Effect of maceration regime on phenolic compound quantity and color quality of madrasa wine samples. *Food Science and Technology, 17 (4).* https://doi.org/10.15673/fst.v17i4.2784

**41.** Bahar, E., Öner, H. (2016). Cabernet-Sauvignon üzüm çeşidinde farklı kültürel işlemlerin verim ve kalite özellikleri üzerine etkileri. *Bahçe, 45 (2),* 591–598. Available at: https://dergipark.org.tr/tr/pub/bahce/article/1805641

**42.** Korkutal, İ., Bahar, E., Güvemli Dündar, D. (2019). Ben düşme dönemi ve sonrasında uygulanan antitranspirantların 'Cabernet Sauvignon' üzüm çeşidinde şıra özellikleri ve verime etkileri. *Akademik Ziraat Dergisi, 8 (2),* 173–184. https://doi.org/10.29278/azd.584170


DOI: 10.15587/2706-5448.2026.353165

## IMPROVEMENT OF THE MODEL OF STRUCTURAL-MECHANICAL AND THIXOTROPIC PROPERTIES OF MEAT BATTERS

**pages 38–44**

***Ihor Oshchypok,*** *Doctor of Technical Sciences, Professor, Department of Hotel and Restaurant Business and Food Technologies, Ivan Franko National University of Lviv, Ukraine, ORCID: https://orcid.org/0000-0002-5427-3376*

***Halyna Kushniruk,*** *PhD, Associate Professor, Department of Hotel and Restaurant Business and Food Technologies, Ivan Franko National University of Lviv, Ukraine, e-mail: halyna.kushniruk@lnu.edu.ua, ORCID: https://orcid.org/0000-0002-0242-9746*

***Olia Masliichuk,*** *PhD, Associate Professor, Department of Hotel and Restaurant Business and Food Technologies, Ivan Franko National University of Lviv, Ukraine, ORCID: https://orcid.org/0000-0003-2045-9284*

***Olga Vivcharuk,*** *PhD, Associate Professor, Department of Hotel and Restaurant Business and Food Technologies, Ivan Franko National University of Lviv, Ukraine, ORCID: https://orcid.org/0000-0001-9640-9414*

***Oksana Pauk,*** *PhD, Associate Professor, Department of Hotel and Restaurant Business and Food Technologies, Ivan Franko National University of Lviv, Ukraine, ORCID: https://orcid.org/0009-0004-6134-2773*

The object of research is the thixotropy of meat batters with different ingredient compositions characteristic of sausage products. The research analyzes modern approaches to evaluating the rheological properties of meat emulsion systems and summarizes the factors influencing their structural organization. The regularities of changes in viscous-plastic characteristics of pork and turkey batters under different levels of load are investigated, and the features of structural destruction and recovery are established.

A comprehensive assessment of thixotropic properties is based on the analysis of the structural-mechanical characteristics of batter systems during their formation with various ingredients. It has been demonstrated that the thixotropic state depends on the concentration of protein components and the degree of hydration of the protein system, which determines the stability of the sausage matrix during mechanical processing. The shear stress was calculated for time intervals in the range of 1–1000 s. The output parameters of the proposed model were adapted to the properties of soft meat batters: for minced pork, coefficients $A = 80$ Pa and $B = -12$ were adopted, and for minced turkey, $A = 60$ Pa and $B = -9$. Since the value of B is negative for both types of raw materials, this confirms the presence of pronounced thixotropic properties in the studied systems. Controlling these parameters allows regulation of the thixotropy of the batter to achieve optimal consistency and structural stability of the finished product.

Thixotropic properties play a crucial role in technological operations, including grinding, mixing, filling casings, and structure formation during thermal processing. Excessive structural stability complicates processing, while excessive thixotropy reduces the shape retention of products. The determina-

tion of rheological parameters allows predicting the behavior of batter systems under production conditions, ensuring stable texture and high product quality. The results obtained have practical value for optimizing technological regimes in sausage production and developing new products with predictable rheological properties.

**Keywords:** thixotropy, meat product, sausage products, meat batter, rheological parameters, structural and mechanical properties.

**References**

1. Warren, S. E., Bowker, B., Mohan, A. (2020). Physicochemical properties of beef Tongue as a value-added meat product. *Journal of Food Composition and Analysis, 88.* https://doi.org/10.1016/j.jfca.2020.103433
2. Köppel, R., Ganeshan, A., Weber, S., Pietsch, K., Graf, C., Hochegger, R. et al. (2019). Duplex digital PCR for the determination of meat proportions of sausages containing meat from chicken, turkey, horse, cow, pig and sheep. *European Food Research and Technology, 245 (4),* 853–862. https://doi.org/10.1007/s00217-018-3220-3
3. Harastani, R., James, L. J., Walton, J., Woolley, E. (2020). Tackling obesity: A knowledge-base to enable industrial food reformulation. *Innovative Food Science & Emerging Technologies, 64.* https://doi.org/10.1016/j.ifset.2020.102433
4. Carvalho-Ferreira, J. P. de, da Cunha, D. T., Finlayson, G., Caldas, G., Jamar, G., Bandoni, D. H. et al. (2020). Differential impact of consuming foods perceived to be high or low in fat on subsequent food reward. *Food Quality and Preference, 85.* https://doi.org/10.1016/j.foodqual.2020.103977
5. Rather, S. A., Masoodi, F. A., Rather, J. A., Gani, A., Wani, S. M., Ganaie, T. A., Akhter, R. (2021). Impact of thermal processing and storage on fatty acid composition and cholesterol oxidation of canned traditional low-fat meat product of India. *LWT, 139.* https://doi.org/10.1016/j.lwt.2020.110503
6. Baune, M.-C., Schroeder, S., Witte, F., Heinz, V., Bindrich, U., Weiss, J., Terjung, N. (2021). Analysis of protein-network formation of different vegetable proteins during emulsification to produce solid fat substitutes. *Journal of Food Measurement and Characterization, 15 (3),* 2399–2416. https://doi.org/10.1007/s11694-020-00767-9
7. Boukid, F. (2021). Plant-based meat analogues: from niche to mainstream. *European Food Research and Technology, 247 (2),* 297–308. https://doi.org/10.1007/s00217-020-03630-9
8. He, J., Evans, N. M., Liu, H., Shao, S. (2020). A review of research on plant-based meat alternatives: Driving forces, history, manufacturing, and consumer attitudes. *Comprehensive Reviews in Food Science and Food Safety, 19 (5),* 2639–2656. https://doi.org/10.1111/1541-4337.12610
9. Berger, L. M., Gibis, M., Witte, F., Terjung, N., Weiss, J. (2022). Influence of meat batter addition in ground beef on structural properties and quality parameters. *European Food Research and Technology, 248 (10),* 2509–2520. https://doi.org/10.1007/s00217-022-04065-0
10. Witte, F., Smetana, S., Heinz, V., Terjung, N. (2020). High-pressure processing of usually discarded dry aged beef trimmings for subsequent processing. *Meat Science, 170.* https://doi.org/10.1016/j.meatsci.2020.108241
11. Nortjé, G. L., Nel, L., Jordaan, E., Naudé, R. T., Holzapfel, W. H., Grimbeek, R. J. (1989). A microbiological survey of fresh meat in the supermarket trade. Part 2: beef retail cuts. *Meat Science, 25 (2),* 99–112. https://doi.org/10.1016/0309-1740(89)90025-9
12. Zerabruk, K., Retta, N., Muleta, D., Tefera, A. T. (2019). Assessment of Microbiological Safety and Quality of Minced Meat and Meat Contact Surfaces in Selected Butcher Shops of Addis Ababa, Ethiopia. *Journal of Food Quality.* https://doi.org/10.1155/2019/3902690
13. Terjung, N., Witte, F., Heinz, V. (2021). The dry aged beef paradox: Why dry aging is sometimes not better than wet aging. *Meat Science, 172.* https://doi.org/10.1016/j.meatsci.2020.108355
14. Berger, L. M., Witte, F., Terjung, N., Weiss, J., Gibis, M. (2022). Influence of Processing Steps on Structural, Functional, and Quality Properties of Beef Hamburgers. *Applied Sciences, 12 (15),* 7377. https://doi.org/10.3390/app12157377
15. Davey, C. L., Gilbert, K. V. (1974). Temperature-dependent cooking toughness in beef. *Journal of the Science of Food and Agriculture, 25 (8),* 931–938. Portico. https://doi.org/10.1002/jsfa.2740250808
16. Herrero, A. M., Carmona, P., López-López, I., Jiménez-Colmenero, F. (2008). Raman Spectroscopic Evaluation of Meat Batter Structural Changes Induced by Thermal Treatment and Salt Addition. *Journal of Agricultural and Food Chemistry, 56 (16),* 7119–7124. https://doi.org/10.1021/jf800925s
17. Tornberg, E. (2005). Effects of heat on meat proteins – Implications on structure and quality of meat products. *Meat Science, 70 (3),* 493–508. https://doi.org/10.1016/j.meatsci.2004.11.021
18. Beneke, B. (2018). Technology alters muscle structure: Histological identification and evaluation of meat and meat products. *Fleischwirtschaft, 2,* 62–68.
19. Foegeding, E. A. (1988). Gelation in meat batters. Reciprocal Meat Conference Proceedings, Vol. 41. Laramie, 44–47.
20. Honikel, K. O., Hamm, R.; Pearson, A. M., Dutson, T. R. (Eds.) (1994). Measurement of water-holding capacity and juiciness. *Quality Attributes and Their Measurement in Meat, Poultry and Fish Products.* Boston: Springer, 125–161. https://doi.org/10.1007/978-1-4615-2167-9_5
21. Knipe, C. L.; Dikemann, M. (Ed.) (2024). *Sausages, types of: Emulsion. Encyclopedia of Meat Sciences.* Amsterdam: Elsevier, 425–430. https://doi.org/10.1016/b978-0-323-85125-1.00160-5
22. Tyszkiewicz, I., Kłossowska, B. M., Wieczorek, U., Jakubiec-Puka, A. (1997). Mechanical Tenderisation of Pork Meat: Protein and Water Release due to Tissue Damage. *Journal of the Science of Food and Agriculture, 73 (2),* 179–185. Available at: https://doi.org/10.1002/(sici)1097-0010(199702)73:2<179::aid-jsfa699>3.0.co;2-#
23. Raudsepp, P., Brüggemann, D. A., Henckel, P., Vyberg, M., Groves, K., Oksbjerg, N., Therkildsen, M. (2017). Performance of conventional histochemical methods relative to a novel immunolabeling technique in assessing degree of degradation in comminuted chicken meat. *Food Control, 73,* 133–139. https://doi.org/10.1016/j.foodcont.2016.07.036
24. Irmscher, S. B., Böjthe, Z., Herrmann, K., Gibis, M., Kohlus, R., Weiss, J. (2013). Influence of filling conditions on product quality and machine parameters in fermented coarse meat emulsions produced by high shear grinding and vacuum filling. *Journal of Food Engineering, 117 (3),* 316–325. https://doi.org/10.1016/j.jfoodeng.2013.03.015
25. Leseigneur-Meynier, A., Gandemer, G. (1991). Lipid composition of pork muscle in relation to the metabolic type of the fibres. *Meat Science, 29 (3),* 229–241. https://doi.org/10.1016/0309-1740(91)90052-r
26. Melro, E., Antunes, F., Cruz, I., Ramos, P. E., Carvalho, F., Alves, L. (2020). Morphological, textural and physico-chemical characterization of processed meat products during their shelf life. *Food Structure, 26.* https://doi.org/10.1016/j.foostr.2020.100164
27. Hamm, R. (1975). On the rheology of minced meat. *Journal of Texture Studies, 6 (3),* 281–296. https://doi.org/10.1111/j.1745-4603.1975.tb01126.x
28. Irmscher, S. B., Gibis, M., Herrmann, K., Kohlus, R., Weiss, J. (2016). Development of a novel homogenizer using the vane pump-grinder technology for the production of meat batter. *Journal of Food Engineering, 169,* 10–17. https://doi.org/10.1016/j.jfoodeng.2015.08.022
29. Krökki, A. S. (1995). Fat Concentration in Commercial Minced Meat. *Lipid / Fett, 97 (12),* 466–467. https://doi.org/10.1002/lipi.2700971210
30. Cao, C., Xu, Y., Kong, B., Xia, X., Chen, Q., Zhang, H., Liu, Q. (2023). Changes of rheological behavior, thermal and microstructural properties of myofibrillar protein-κ-carrageenan mixed sol as mediated by NaCl concentration. *Food Bioscience, 55.* https://doi.org/10.1016/j.fbio.2023.103035
31. Momcilova, M. M., Gardinarska-Ivanova, D. N., Yordanov, D. G., Zsivanovits, G. I. (2023). Microstructure and technological properties of cooked meat sausages prepared with emulsions of vegetable oils as substitutes for animal fat. *Food Research, 7 (4),* 22–29. https://doi.org/10.26656/fr.2017.7(4).1030
32. de Huidobro, F. R., Miguel, E., Blázquez, B., Onega, E. (2005). A comparison between two methods (Warner–Bratzler and texture profile analysis) for test-

ISSN-L 2664-9969; E-ISSN 2706-5448

ing either raw meat or cooked meat. *Meat Science, 69 (3),* 527–536. https://doi.org/10.1016/j.meatsci.2004.09.008

**33.** Dzudie, T., Scher, J., Hardy, J., Sanchez, C. (2000). Physico-chemical and rheological properties of low-fat, high-added water beef sausage extended with common bean flour. *Journal of Muscle Foods, 11 (2),* 129–142. https://doi.org/10.1111/j.1745-4573.2000.tb00420.x

**34.** Profeta, A., Baune, M.-C., Smetana, S., Bornkessel, S., Broucke, K., Van Royen, G., Enneking, U., Weiss, J., Heinz, V., Hieke, S., Terjung, N. (2021). Preferences of German Consumers for Meat Products Blended with Plant-Based Proteins. *Sustainability, 13 (2),* 650. https://doi.org/10.3390/su13020650

DOI: 10.15587/2706-5448.2026.353167

## DETERMINATION OF THE INFLUENCE OF ROSEHIP POWDER ON THE QUALITY OF WHEAT DOUGH AND BREAD

**pages 45–50**

***Svitlana Oliinyk,*** *PhD, Professor, Department of Bakery and Confectionery Technology, State Biotechnological University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-4127-8247, e-mail: svitlana.oliinyk@gmail.com*

***Olga Samokhvalova,*** *PhD, Professor, Department of Bakery and Confectionery Technology, State Biotechnological University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-9303-6883*

***Bohdan Bilash,*** *PhD Student, Department of Bakery and Confectionery Technology, State Biotechnological University, Kharkiv, Ukraine, ORCID: https://orcid.org/0009-0003-6969-862X*

***Olena Bolkhovitina,*** *PhD, Associate Professor, Department of Bakery and Confectionery Technology, State Biotechnological University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0001-8949-1755*

The object of the research is the technology of wheat bread. The problem of creating high-quality bakery products using natural non-traditional raw materials with a high content of physiologically functional nutrients is solved. For this purpose, it is proposed to use rosehip powder. The introduction of non-traditional raw materials into the dough affects not only the nutritional value, but also the formation of bread quality. In this regard, the work investigated the effect of rosehip powder on the properties of wheat flour, as well as the processes of dough ripening, organoleptic and physicochemical properties of products. It was found that the introduction of rosehip powder in an amount of 2.0–8.0% to replace wheat flour contributes to the strengthening of gluten, namely, increasing elasticity and reducing gluten extensibility, reducing dough spreading, and improving the gas-holding capacity of the dough. This is explained by the oxidative action of ascorbic acid, the formation of complexes of gluten protein with polyphenols and dietary fibers of rosehip powder.

It was found that in the presence of rosehip fruit powder, lactic acid and alcoholic fermentation are activated, which contributes to more intense changes in acid accumulation and gas formation in the dough due to the activation of lactic acid bacteria and baker's yeast in the presence of biologically active substances of the additive.

The use of rosehip powder in an amount of 2.0–6.0% contributes to an increase in the specific volume, porosity and elasticity of the crumb, the formation of harmonious taste and aromatic properties of products with characteristic rosehip notes. The introduction of 8.0% of the additive is not recommended, as it leads to the formation of coarser porosity, too sharp sour taste of the additive and crunch.

The results obtained can be used in the practice of baking production to develop a technology for bread of increased nutritional value using rosehip powder.

**Keywords:** wheat bread, rosehip powder, gluten, dough ripening, quality indicators.

**References**

**1.** Sagbas, H. I. (2023). Investigation of Fruit Quality and Biochemical Traits of Rosehip (R. canina) Ecotypes in the Aegean Region of Türkiye. *Horticulturae, 9 (12),* 1292. https://doi.org/10.3390/horticulturae9121292

**2.** Peña, F., Valencia, S., Tereucán, G., Nahuelcura, J., Jiménez-Aspee, F., Cornejo, P., Ruiz, A. (2023). Bioactive Compounds and Antioxidant Activity in the Fruit of Rosehip (*Rosa canina L. and Rosa rubiginosa L.*). *Molecules, 28 (8),* 3544. https://doi.org/10.3390/molecules28083544

**3.** Ionescu, A.-D., Voicu, G., Stefan, E.-M., Constantin, G.-A., Tudor, P., Militaru, G. (2025). Physico-Chemical and Resistance Characteristics of Rosehip Seeds. *Agriculture, 15 (14),* 1539. https://doi.org/10.3390/agriculture15141539

**4.** Chrubasik, C., Roufogalis, B. D., Müller-Ladner, U., Chrubasik, S. (2008). A systematic review on the Rosa canina effect and efficacy profiles. *Phytotherapy Research, 22 (6),* 725–733. https://doi.org/10.1002/ptr.2400

**5.** Drobot, V. I. (2024) *Tekhnolohiia khlibopekarskoho vyrobnytstva.* Kyiv: Vydavnytstvo ProfKnyha, 516.

**6.** Vartolomei, N., Turtoi, M. (2023). Effect of Rosehip Powder Addition on Dough Extensographic, Amylographic and Rheofermentographic Properties and Sensory Attributes of Bread. *Processes, 11 (4),* 1088. https://doi.org/10.3390/pr11041088

**7.** Vartolomei, N., Turtoi, M. (2021). The influence of the addition of rosehip powder to wheat flour on the dough farinographic properties and bread physico-chemical characteristics. *Applied Sciences, 11 (24),* 12035. https://doi.org/10.3390/app112412035

**8.** Boz, H., Murat Karaoğlu, M., Gürbüz Kotancilar, H., Emre Gerçekaslan, K. (2010). The effects of different materials as dough improvers for organic whole wheat bread. *International Journal of Food Science & Technology, 45 (7),* 1472–1477. https://doi.org/10.1111/j.1365-2621.2010.02289.x

**9.** Ivanova, P., Chochkov, R., Zlateva, D., Stefanova, D. (2023). Total phenolic and flavonoid content, and antioxidant activity of wheat bread enriched with pumpkin, chestnut and rosehip flour. *Carpathian Journal of Food Science and Technology. 15 (2),* 33–41. https://doi.org/10.34302/crpjfst/2023.15.2.4

**10.** Chochkov, R., Zlateva, D., Ivanova, P., Stefanova, D. (2022). Effect of rosehip flour on the properties of wheat dough and bread. *Ukrainian Food Journal, 11 (4),* 558–572. https://doi.org/10.24263/2304-974x-2022-11-4-6

**11.** Oliinyk, S., Samokhvalova, O., Lapitskaya, N. (2019). The influence of meal of rose hips on the ripening and quality of rye-wheat bread. *Scientific Works of National University of Food Technologies, 25 (6),* 249–258. https://doi.org/10.24263/2225-2924-2019-25-6-31

**12.** Oliinyk, S., Samokhvalova, O., Lapitska, N., Kucheruk, Z. (2020). Studying the influence of meats from wheat and oat germs, and rose hips, on the formation of quality of rye wheat dough and bread. *Eastern-European Journal of Enterprise Technologies, 1 (11 (103)),* 59–65. https://doi.org/10.15587/1729-4061.2020.187944

**13.** Lapytska, H., Syza, O., Gorodyska, O., Savchenko, O., Rebenok, E. (2022). The impact of rosehip oil on quality of rye-wheat bread. *Biota. Human. Technology, 2,* 106–117. https://doi.org/10.58407/bht.2.22.8

**14.** Gül, H., Şen, H. (2017). The influence of rosehip seed flour on bread quality. *Scientific Bulletin. Biotechnologies. F, 21,* 336–342. Available at: http://biotechnologyjournal.usamv.ro/pdf/2017/vol2017.pdf

**15.** Lebedenko, T., Korkach, H., Kozhevnikova, V., Novichkova, T. (2019). Methods of regulating physical properties of dough using phytoextracts. *Food Science and Technology, 12 (4),* 52–62. https://doi.org/10.15673/fst.v12i4.1182

**16.** Pop, I.-A., Dossa, S., Stoin, D., Neagu, C., Moigradean, D., Alexa, E., Poiana, M.-A. (2025). Nutritional, Rheological, and Functional Assessment in the Development of Bread Using Chestnut and Rosehip-Fortified Wheat Flour. *Foods, 14 (19),* 3343. https://doi.org/10.3390/foods14193343

**17.** Alashbayeva, L., Kenzhekhojayev, M., Borankulova, A., Muldabekova, B., Yakiyayeva, M., Tursunbayeva, S., Dyusembaeva, Z. (2024). Enhancing the quality of wholemeal bread with chia, sesame, and rosehip: mathematical modelling and organoleptic analysis. *Potravinarstvo Slovak Journal of Food Sciences, 18,* 993–1005. https://doi.org/10.5219/2006

**18.** Drobot, V. I. (2015). *Tekhnokhimichnyi kontrol syrovyny ta khlibobulochnykh i makaronnykh vyrobiv*. Kyiv: Kondor-Vydavnytstvo, 972.
**19.** Drobot, V. I. (2006). *Laboratornyi praktykum z tekhnolohii khlibopekarskoho i makaronnoho vyrobnytstva*. Kyiv: Tsentr navchalnoi literatury, 341.
**20.** Drobot, V. I. (2019). *Dovidnyk z tekhnolohii khlibopekarskoho vyrobnytstva. Dovidnyk*. Kyiv: ProfKnyha, 580.
**21.** Oliinyk, S., Samokhvalova, O.; Gubsky, S., Stabnikova, O., Stabnikov, V., Paredes-López, O. (Eds.) (2025). Wild Edible Plants Used in Bakery Production. *Wild Edible Plants*. CRC Press, 268–293. https://doi.org/10.1201/9781003486794-10
**22.** Elkassabany, M., Hoseney, R. C. (1980). Ascorbic acid as an oxidant in wheat flour dough. II. Rheological effects. *Cereal Chemistry, 57 (2),* 88–91. Available at: https://www.cerealsgrains.org/publications/cc/backissues/1980/Documents/chem57_88.pdf
**23.** Samokhvalova, O. V., Chernikova, Yu. O., Oliinyk, S. H., Kasabova, K. R. (2015). The effect of microbial polysaccharides on the properties of wheat flour. *Eastern-European Journal of Enterprise Technologies, 6 (10 (77)), 11*–15. https://doi.org/10.15587/1729-4061.2015.56177
**24.** Welc-Stanowska, R., Kłosok, K., Nawrocka, A. (2023). Effects of gluten-phenolic acids interaction on the gluten structure and functional properties of gluten and phenolic acids. *Journal of Cereal Science, 111*, 103682. https://doi.org/10.1016/j.jcs.2023.103682
**25.** Krekora, M., Miś, A., Nawrocka, A. (2021). Molecular interactions between gluten network and phenolic acids studied during overmixing process with application of FT-IR spectroscopy. *Journal of Cereal Science, 99,* 103203. https://doi.org/10.1016/j.jcs.2021.103203
**26.** Du, J., Dang, M., Khalifa, I., Du, X., Xu, Y., Li, C. (2020). Persimmon tannin changes the properties and the morphology of wheat gluten by altering the cross-linking, and the secondary structure in a dose-dependent manner. *Food Research International, 137,* 109536. https://doi.org/10.1016/j.foodres.2020.109536
**27.** Wu, Y., Liu, Y., Jia, Y., Zhang, H., Ren, F. (2024). Formation and Application of Starch–Polyphenol Complexes: Influencing Factors and Rapid Screening Based on Chemometrics. *Foods, 13 (10),* 1557. https://doi.org/10.3390/foods13101557

DOI: 10.15587/2706-5448.2026.353035

## EVALUATION OF TECHNOLOGICAL PROPERTIES AND SAFETY INDICATORS OF POULTRY PRODUCTS MADE USING NATURAL MARINADES

**pages 51–58**

***Vasyl Tischenko,*** *PhD, Associate Professor, Department of Technology and Food Safety, Sumy National Agricultural University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0001-8149-4919*

***Svitlana Huba,*** *PhD Student, Department of Technology and Food Safety, Sumy National Agricultural University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0002-0546-7940*

***Nataliia Bozhko,*** *Doctor of Technical Sciences, Associate Professor, Department of Technology and Food Safety, Sumy National Agricultural University, Sumy, Ukraine, e-mail: natalybozhko@ukr.net, ORCID: https://orcid.org/0000-0001-6440-0175*

The object of research is the technology and quality parameters of marinated semi-finished poultry meat products using marinades based on cherry juice of the Chernokorka variety (Cherry tree Chernokorka) and Josta berries (Josta). The problem solved in the research is the lack of an exhaustive definition of the influence of natural marinades on the complex of indicators of natural semi-finished poultry meat products. The key evaluation parameters were: color, pH, moisture retention capacity, marinade absorption, losses during heat treatment, sensory indicators, safety indicators of finished products. The process of passive marinating (soaking) was carried out for 12 hours. For this, chicken breasts were soaked in marinade solutions No. 1 (josta berry juice: purified water: sea salt – 60:37:3) and No. 2 (cherry berry juice: purified water: sea salt – 60:37:3). As a control, samples were marinated in marinades of the company Spice Land LLC (Ukraine).

It was found that the juice of josta berries differs from cherry juice in a higher content of total phenolic compounds (327.16 versus 201.31 mg/100 ml) and a higher titrated acidity (3.5%). The antioxidant activity of josta juice is at a high level: juice polyphenols inhibit 97.41 ± 1.57% of the DPPH free radical. An increase in moisture content was determined in products marinated with cherry juice (76.21%) and josta juice (77.16%). The use of cherry and josta juice in marinades accelerates their diffusion into muscle tissue. The highest sorption capacity was found in samples treated with marinade with josta juice (1.43%), which is 1.5 times higher than the control. The use of berry juices in marinades reduces thermal losses by 2.17–2.68%.

It has been proven that the use of cherry and josta juice as bases for marinades in the technology of semi-finished poultry meat products improves the taste and aroma profile of finished products, inhibits oxidative processes in marinated semi-finished poultry meat products, and ensures their microbiological safety during storage.

**Keywords:** marinated meat semi-finished products, cherry juice, josta juice, marinade absorption, antioxidant activity.

**References**

**1.** Figueroa, C., Ramírez, C., Núñez, H., Jaques, A., Simpson, R. (2020). Application of vacuum impregnation and $CO_2$-laser microperforations in the potential acceleration of the pork marinating process. *Innovative Food Science & Emerging Technologies, 66,* 102500. https://doi.org/10.1016/j.ifset.2020.102500
**2.** Gazda, P., Glibowski, P. (2024). Advanced Technologies in Food Processing – Development Perspective. *Applied Sciences, 14 (9),* 3617. https://doi.org/10.3390/app14093617
**3.** Demir, H., Çelik, S., Sezer, Y. Ç. (2021). Effect of ultrasonication and vacuum impregnation pretreatments on the quality of beef marinated in onion juice a natural meat tenderizer. *Food Science and Technology International, 28 (4),* 340–352. https://doi.org/10.1177/10820132211012919
**4.** Augustyńska-Prejsnar, A., Sokołowicz, Z., Hanus, P., Ormian, M., Kačániová, M. (2020). Quality and Safety of Marinating Breast Muscles of Hens from Organic Farming after the Laying Period with Buttermilk and Whey. *Animals, 10 (12),* 2393. https://doi.org/10.3390/ani10122393
**5.** Manful, C. F., Pham, T. H., Nadeem, M., Wheeler, E., Warren, K. J. T., Vidal, N. P., Thomas, R. H. (2021). Assessing unfiltered beer-based marinades effects on ether and ester linked phosphatidylcholines and phosphatidylethanolamines in grilled beef and moose meat. *Meat Science, 171,* 108271. https://doi.org/10.1016/j.meatsci.2020.108271
**6.** Ehsanur Rahman, S. M., Islam, S., Pan, J., Kong, D., Xi, Q., Du, Q. et al. (2023). Marination ingredients on meat quality and safety – a review. *Food Quality and Safety, 7.* https://doi.org/10.1093/fqsafe/fyad027
**7.** Augustyńska-Prejsnar, A., Kačániová, M., Ormian, M., Topczewska, J., Sokołowicz, Z. (2023). Quality and Microbiological Safety of Poultry Meat Marinated with the Use of Apple and Lemon Juice. *International Journal of Environmental Research and Public Health, 20 (5),* 3850. https://doi.org/10.3390/ijerph20053850
**8.** Latoch, A., Czarniecka-Skubina, E., Moczkowska-Wyrwisz, M. (2023). Marinades Based on Natural Ingredients as a Way to Improve the Quality and Shelf Life of Meat: A Review. *Foods, 12 (19),* 3638. https://doi.org/10.3390/foods12193638
**9.** Peshuk, L., Kyrylov, Y., Shtyk, I., Chernushenko, O. (2022). Technology of marined game semi-finished meat with an accent of elegance and functionality. *Journal of Chemistry and Technologies, 30 (4),* 639–651. https://doi.org/10.15421/jchemtech.v30i4.268176
**10.** Tyshchenko, L. M., Pylypchuk, O., Adamchuk, L. O., Akulonok, O. I. (2021). Honey as a component of marinade for semi-finished meat products. *Animal Science and Food Technology, 12 (2),* 73–81. https://doi.org/10.31548/animal2021.02.008

ISSN-L 2664-9969; E-ISSN 2706-5448


**11.** Edema, W. N., Jayarathne, G. G. N., Udayanga, D., Senevirathne, T. A. S. M., Jayasena, D. D. (2020). Effect of different marinades with bee honey and pineapple on quality attributes of smoked chicken jerky. *Proceedings of the International Research Conference of Uva Wellassa University*. Badulla: Uva Wellassa University, 283.

**12.** Lopes, S. M., da Silva, D. C., Tondo, E. C. (2021). Bactericidal effect of marinades on meats against different pathogens: a review. *Critical Reviews in Food Science and Nutrition, 62 (27),* 7650–7658. https://doi.org/10.1080/10408398.2021.1916734

**13.** Serdaroğlu, M., Öztürk-Kerimoğlu, B. (2023). *Et Teknolojisi Et Ürünleri Üretiminde Temel Teknolojiler ve Ürün Kalitesi*. Sidas, 316.

**14.** Bhat, Z. F., Morton, J. D., Mason, S. L., Bekhit, A. E. A. (2018). Applied and Emerging Methods for Meat Tenderization: A Comparative Perspective. *Comprehensive Reviews in Food Science and Food Safety, 17 (4),* 841–859. https://doi.org/10.1111/1541-4337.12356

**15.** Barekat, S., Soltanizadeh, N. (2017). Improvement of meat tenderness by simultaneous application of high-intensity ultrasonic radiation and papain treatment. *Innovative Food Science & Emerging Technologies, 39,* 223–229. https://doi.org/10.1016/j.ifset.2016.12.009

**16.** Bekhit, A. E.-D. A., Suwandy, V., Carne, A., van de Ven, R., Hopkins, D. L. (2016). Effect of repeated pulsed electric field treatment on the quality of hot-boned beef loins and topsides. *Meat Science, 111,* 139–146. https://doi.org/10.1016/j.meatsci.2015.09.001

**17.** Simonova, I., Tsizh, B., Drachuk, U., Halukh, B., Basarab, I., Koval, H. et al. (2024). The utilization of new types of marinades based on fruit raw material for use in the technology of semi-finished rabbit meat. *Zywnosc Nauka Technologia Jakosc/Food Science Technology Quality, 31 (2),* 46–66. https://doi.org/10.15193/zntj/2024/139/496

**18.** Laczkó-Zöld, E., Komlósi, A., Ülkei, T., Fogarasi, E., Croitoru, M., Fülöp, I. et al. (2018). Extractability of polyphenols from black currant, red currant and gooseberry and their antioxidant activity. *Acta Biologica Hungarica, 69 (2),* 156–169. https://doi.org/10.1556/018.69.2018.2.5

**19.** Yalpachyk, V. F., Zahorko, N. P., Kiurchev, S. V., Tarasenko, V. H., Kiurcheva, L. M., Budenko, S. F. et al. (2018). *Optymizatsiia tekhnolohii zamorozhuvannia plodoovochevoi produktsii.* Melitopol: Vydavnychyi budynok Melitopolskoi miskoi drukarni, 214.

**20.** Untea, A. E., Oancea, A.-G., Vlaicu, P. A., Varzaru, I., Saracila, M. (2024). Blackcurrant (Fruits, Pomace, and Leaves) Phenolic Characterization before and after In Vitro Digestion, Free Radical Scavenger Capacity, and Antioxidant Effects on Iron-Mediated Lipid Peroxidation. *Foods, 13 (10),* 1514. https://doi.org/10.3390/foods13101514

**21.** Carvalho, F., Lahlou, R. A., Silva, L. R. (2024). Phenolic Compounds from Cherries and Berries for Chronic Disease Management and Cardiovascular Risk Reduction. *Nutrients, 16 (11),* 1597. https://doi.org/10.3390/nu16111597

**22.** Nour, V. (2022). Effect of Sour Cherry or Plum Juice Marinades on Quality Characteristics and Oxidative Stability of Pork Loin. *Foods, 11 (8),* 1088. https://doi.org/10.3390/foods11081088

**23.** Clodoveo, M. L., Crupi, P., Muraglia, M., Naeem, M. Y., Tardugno, R., Limongelli, F., Corbo, F. (2023). The main phenolic compounds responsible for the antioxidant capacity of sweet cherry (*Prunus avium L.*) pulp. *LWT, 185,* 115085. https://doi.org/10.1016/j.lwt.2023.115085

**24.** Bozhko, N., Pasichnyi, V., Tischenko, V., Marynin, A., Shubina, Y., Strashynskyi, I. (2021). Determining the nutritional value and quality indicators of meat-containing bread made with hemp seeds flour (*Cannabis sativa L.*). *Eastern-European Journal of Enterprise Technologies, 4 (11 (112)),* 58–65. https://doi.org/10.15587/1729-4061.2021.237806

**25.** Bozhko, N., Pasichnyi, V., Marynin, A., Tischenko, V., Strashynskyi, I., Kyselov, O. (2020). The efficiency of stabilizing the oxidative spoilage of meat-containing products with a balanced fat-acid composition. *Eastern-European Journal of Enterprise Technologies, 3 (11 (105)),* 38–45. https://doi.org/10.15587/1729-4061.2020.205201

**26.** Abd-Elhalim, B. T., Mohamed, E. S., Gamar, G. M., Moawad, H. (2025). Biological activities and application of Rosmarinus officinalis extract to improve the preservation and microbial qualities of some local meat products. *Scientific Reports, 15 (1).* https://doi.org/10.1038/s41598-025-14247-x

**27.** Kang, J.-Y., Lee, S.-H., Jo, A.-H., Park, E.-J., Bak, Y.-S., Kim, J.-B. (2020). Improving the accuracy of coliform detection in meat products using modified dry rehydratable film method. *Food Science and Biotechnology, 29 (9),* 1289–1294. https://doi.org/10.1007/s10068-020-00778-8

**28.** Modzelewska-Kapituła, M., Tkacz, K., Nogalski, Z. (2021). The influence of muscle, ageing and thermal treatment method on the quality of cooked beef. *Journal of Food Science and Technology, 59 (1),* 123–132. https://doi.org/10.1007/s13197-021-04993-x

**29.** Bulgaru, V., Gurev, A., Baerle, A., Dragancea, V., Balan, G., Cojocari, D. et al. (2024). Phytochemical, Antimicrobial, and Antioxidant Activity of Different Extracts from Frozen, Freeze-Dried, and Oven-Dried Jostaberries Grown in Moldova. *Antioxidants, 13 (8),* 890. https://doi.org/10.3390/antiox13080890

**30.** Vahapoglu, B., Erskine, E., Gultekin Subasi, B., Capanoglu, E. (2021). Recent Studies on Berry Bioactives and Their Health-Promoting Roles. *Molecules, 27 (1),* 108. https://doi.org/10.3390/molecules27010108

**31.** Okatan, V. (2020). Antioxidant properties and phenolic profile of the most widely appreciated cultivated berry species: A comparative study. *Folia Horticulturae, 32 (1),* 79–85. https://doi.org/10.2478/fhort-2020-0008

**32.** Unal, K., Alagöz, E., Çelik, İ., Sarıçoban, C. (2021). Marination with citric acid, lemon, and grapefruit affects the sensory, textural, and microstructure characteristics of poultry meat. *British Poultry Science, 63 (1),* 31–38. https://doi.org/10.1080/00071668.2021.1963674

**33.** Dilek, N. M., Babaoğlu, A. S., Unal, K., Ozbek, C., Pırlak, L., Karakaya, M. (2023). Marination with aronia, grape and hawthorn vinegars affects the technological, textural, microstructural and sensory properties of spent chicken meat. *British Poultry Science, 64 (3),* 357–363. https://doi.org/10.1080/00071668.2022.2163616

**34.** Komoltri, P., Pakdeechanuan, P. (2012). Effects of marinating ingredients on physicochemical, microstructural and sensory properties of golek chicken. *International Food Research Journal, 19,* 1449–1455.

**35.** Mohd Azmi, S., Kumar, P., Sharma, N., Sazili, A., Lee, S.-J., Ismail-Fitry, M. (2023). Application of Plant Proteases in Meat Tenderization: Recent Trends and Future Prospects. *Foods, 12 (6),* 1336. https://doi.org/10.3390/foods12061336

**36.** Pylypchuk, O., Tyshchenko, L., Israelian, V., Mushtruk, N. (2022). Influence of parameters of marinating meat semi-finished products on the quality of the finished product. *Animal Science and Food Technology, 13 (2),* 44–52. https://doi.org/10.31548/animal.13(2).2022.44-52

**37.** Al-Dalali, S., Li, C., Xu, B. (2021). Evaluation of the effect of marination in different seasoning recipes on the flavor profile of roasted beef meat via chemical and sensory analysis. *Journal of Food Biochemistry, 46 (6).* https://doi.org/10.1111/jfbc.13962

**38.** Simonova, I., Halukh, B., Drachuk, U., Basarab, I. (2023). Improvement of poultry meat marinated semi-finished product technology. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies, 25 (99),* 61–68. https://doi.org/10.32718/nvlvet-f9911

**39.** Borodai, A. B., Sutkovych, T. Yu., Heredchuk, A. M., Levchenko, Yu. V. (2024). Improvement pre-treatment technology of meat for the preparation in restaurants. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies, 26 (101),* 84–90. https://doi.org/10.32718/nvlvet-f10113

**40.** Das, A., Hashem, M. A., Azad, M. A. K., Rahman, M. M. (2022). Marinating broiler meat in cooking oil for short-term storage. *Meat Research, 2 (3).* https://doi.org/10.55002/mr.2.3.22

**41.** Gök, V., Bor, Y. (2016). Effect of Marination with Fruit and Vegetable Juice on the Some Quality Characteristics of Turkey Breast Meat. *Revista Brasileira de Ciência Avícola, 18 (3),* 481–488. https://doi.org/10.1590/1806-9061-2016-0225

**42.** Kadıoğlu, P., Karakaya, M., Unal, K., Babaoğlu, A. S. (2019). Technological and textural properties of spent chicken breast, drumstick and thigh meats as affected

by marinating with pineapple fruit juice. *British Poultry Science, 60 (4),* 381–387. https://doi.org/10.1080/00071668.2019.1621990

**43.** Barbanti, D., Pasquini, M. (2005). Influence of cooking conditions on cooking loss and tenderness of raw and marinated chicken breast meat. *LWT – Food Science and Technology, 38 (8),* 895–901. https://doi.org/10.1016/j.lwt.2004.08.017

**44.** Filipović, I., Ćurčić, B., Filipović, V., Nićetin, M., Filipović, J., Knežević, V. (2016). The Effects of Technological Parameters on Chicken Meat Osmotic Dehydration Process Efficiency. *Journal of Food Processing and Preservation, 41 (1),* e13116. https://doi.org/10.1111/jfpp.13116

**45.** Peshuk, L. V., Prykhodko, D. Yu., Shtyk, I. I. (2024). Vplyv kavovoho marynadu na optymizatsiiu yakisnykh pokaznykiv miasnykh napivfabrykativ iz dychyny. *Tavriiskyi naukovyi visnyk. Seriia: Tekhnichni nauky, 5*, 131–139.

**46.** Klementaviciute, J., Zavistanaviciute, P., Klupsaite, D., Rocha, J. M., Gruzauskas, R., Viskelis, P. et al. (2024). Valorization of Dairy and Fruit/Berry Industry By-Products to Sustainable Marinades for Broilers' Wooden Breast Meat Quality Improvement. *Foods, 13 (9),* 1367. https://doi.org/10.3390/foods13091367

**47.** Bozhko, N., Pasichnyi, V., Tischenko, V., Marynin, A., Vasylyshyn, K.; Gubsky, S., Stabnikova, O., Stabnikov, V., Paredes-López, O. (Eds.) (2025). Antioxidants from Wild Plants in Meat and Meat Products. *Wild Edible Plants.* Boca Raton: CRC Press, 243–267. https://doi.org/10.1201/9781003486794-9

**48.** Pasichniy, V., Tischenko, V., Bozhko, N., Koval, O., Marynin, A. (2022). Use of bioactive properties of plant extracts to increase the storage stability of mechanically separated turkey meat. *Ukrainian Food Journal, 11 (4),* 616–628. https://doi.org/10.24263/2304-974x-2022-11-4-10

**49.** Rupasinghe, R. A., Alahakoon, A. U., Alakolanga, A. W., Jayasena, D. D., Jo, C. (2022). Oxidative Stability of Vacuum-Packed Chicken Wings Marinated with Fruit Juices during Frozen Storage. *Food Science of Animal Resources, 42 (1),* 61–72. https://doi.org/10.5851/kosfa.2021.e62

**50.** Mani-López, E., García, H. S., López-Malo, A. (2012). Organic acids as antimicrobials to control Salmonella in meat and poultry products. *Food Research International, 45 (2),* 713–721. https://doi.org/10.1016/j.foodres.2011.04.043

**51.** Meneses, R., Teixeira, P. (2022). Marination as a Hurdle to Microbial Pathogens and Spoilers in Poultry Meat Products: A Brief Review. *Applied Sciences, 12 (22),* 11774. https://doi.org/10.3390/app122211774