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DETERMINATION OF THE EXPLOITATION PARAMETERS OF THE BLED EL HADBA PHOSPHATE DEPOSIT, ALGERIA

pages 6–14

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The beneficiation of mineral resources not only bolsters a country's economy but also improves quality of life and fosters sustainable growth. The development of the phosphate mine in the Bled El Hadba region represents a pivotal move to meet increasing demand. This study aims to develop a comprehensive 3D geographic model of the deposit, estimate its phosphate reserves, and assess the parameters and characteristics for effective exploitation. Utilizing the block model method in Surpac 6.6.2, a detailed analysis is achieved that supports informed decision-making for sustainable resource management. This approach underscores the importance of technological innovation in the strategic planning and efficient utilization of mineral resources.

The results revealed total reserves of 425,304,000 m^3, equivalent to 893,138,400 tons, with an average grade of 21.65 %. The stripping ratio was determined to be 3.3:1. These findings provide valuable insights into the deposit's potential and the optimal depth range for extracting the highest concentration of P_2O_5. For detailed extraction planning and estimating P_2O_5 concentration over five-year periods from 2023 to 2066, with an average annual phosphate ore production of 20.7 million tons, Minesched software was utilized. This comprehensive approach ensures efficient resource management and maximizes the economic return from the deposit. These findings have profound implications for enhancing both the efficiency and sustainability of Algeria's mining industry. By securing a consistent supply of phosphate products, particularly for agriculture, this research addresses the rising demand for phosphates. Additionally, the data can inform strategic planning, enabling optimized resource extraction and reduced environmental impact. This contributes not only to the immediate needs of the industry but also to the long-term economic and ecological sustainability of the region. Ultimately, the study supports sustainable development by balancing industrial growth with environmental stewardship, ensuring that future generations can continue to benefit from these vital resources.

Keywords: exploitable reserves, phosphate, highest concentration of P_2O_5, rational mining, Surpac 6.6.2 and Minesched.

References

1. Gorman, M. R., Dzombak, D. A. (2018). A review of sustainable mining and resource management: Transitioning from the life cycle of the mine to the life cycle of the mineral. *Resources, Conservation and Recycling, 137,* 281–291. https://doi.org/10.1016/j.resconrec.2018.06.001
2. Batterham, R. J. (2017). The mine of the future – Even more sustainable. *Minerals Engineering, 107,* 2–7. https://doi.org/10.1016/j.mineng.2016.11.001
3. Monteiro, N. B. R., da Silva, E. A., Moita Neto, J. M. (2019). Sustainable development goals in mining. *Journal of Cleaner Production, 228,* 509–520. https://doi.org/10.1016/j.jclepro.2019.04.332
4. Rooki, R., Mohammadi, M. N., Safari, M. (2022). Reserve estimation of IV deposit of Sangan iron ore mine using Geostatistical method and SURPAC software. *Journal of Mining Engineering, 7 (56),* 21–39. https://doi.org/10.22034/ijme.2022.537596.1879
5. Zeqiri, R. (2021). Nickel discretization and quality review in Gllavica mine, Kosovo. *Mining of Mineral Deposits, 15 (1),* 35–41. https://doi.org/10.33271/mining15.01.035
6. Verhoeven, G. J. (2016). Mesh Is More – Using All Geometric Dimensions for the Archaeological Analysis and Interpretative Mapping of 3D Surfaces. *Journal of Archaeological Method and Theory, 24 (4),* 999–1033. https://doi.org/10.1007/s10816-016-9305-z
7. Wang, C., Wang, G., Liu, J., Zhang, D. (2019). 3D geochemical modeling for subsurface targets of Dashui Au deposit in Western Qinling (China). *Journal of Geochemical Exploration, 203,* 59–77. https://doi.org/10.1016/j.gexplo.2019.04.003
8. Bester, M. (2019). *Heritage impact assessment Northan zondereinde platinum mine 3 shaft.* Thabazimbi local municipality report N° LP30/5/1/2/3/2/1/(037) EM.
9. Qudrat-Ullah, H., Panthallor, P. N. (2021). *Operational Sustainability in the Mining Industry: The Case of Large-Scale Open-Pit Mining (LSOPM) Operations.* Springer Nature. https://doi.org/10.1007/978-981-15-9027-6
10. Prian, G. P., Cortiel, P. (1993). *Etude de développement du gisement de phosphate de Djebel Onk (Algérie).* Rapport d'expertise géologique. BRGM France 288.
11. Sahoo, M. M., Pal, B. K. (2017). Geological modelling of a deposit and application using Surpac. *Journal of Mines, Metals and Fuels, 65 (7),* 417–422.
12. Fengyu, R. E. N., Huan, L. I. U., Rongxing, H. E., Guanghui, L. I., Yang, L. I. U. (2019). The spatial distribution of rock mass basic quality of the Luoboling copper-molybdenum mine based on SURPAC software. *China Mining Magazine, 28 (9),* 80–84. https://doi.org/10.12075/j.issn.1004-4051.2019.09.014
13. Mohammadpour, M., Bahroudi, A., Abedi, M. (2021). Three dimensional mineral prospectivity modeling by evidential belief functions, a case study from Kahang porphyry Cu deposit. *Journal of African Earth Sciences, 174,* 104098. https://doi.org/10.1016/j.jafrearsci.2020.104098
14. Jowitt, S. M., McNulty, B. A. (2021). Geology and Mining: Mineral Resources and Reserves: Their Estimation, Use, and Abuse. *SEG Discovery, 125,* 27–36. https://doi.org/10.5382/geo-and-mining-11
15. Jooshaki, M., Nad, A., Michaux, S. (2021). A Systematic Review on the Application of Machine Learning in Exploiting Mineralogical Data in Mining and Mineral Industry. *Minerals, 11 (8),* 816. https://doi.org/10.3390/min11080816
16. Nwaila, G. T., Zhang, S. E., Bourdeau, J. E., Frimmel, H. E., Ghorbani, Y. (2023). Spatial Interpolation Using Machine Learning: From Patterns and Regularities to Block Models. *Natural Resources Research, 33 (1),* 129–161. https://doi.org/10.1007/s11053-023-10280-7
17. Charles Amadu, C., Foli, G., Abrokwa, B. K., Akpah, S. (2020). Geostatistical approach for the estimation of shear-hosted gold deposit: a case study of the obuasi gold deposit, Ghana. *Malaysian Journal of Geosciences, 5 (2),* 76–84. https://doi.org/10.26480/mjg.02.2021.76.84

18. Appianing, J., Van Eck, R. N. (2015). Gender differences in college students' perceptions of technology-related jobs in computer science. *International Journal of Gender, Science and Technology, 7 (1),* 28–56. Available at: https://genderandset.open.ac.uk/index.php/genderandset/article/view/351
19. Uyan, M., Dursun, A. E. (2021). Determination and modeling of lignite reserve using geostatistical analysis and GIS. *Arabian Journal of Geosciences, 14 (4).* https://doi.org/10.1007/s12517-021-06633-2
20. Qu, H., Liu, H., Tan, K., Zhang, Q. (2021). Geological Feature Modeling and Reserve Estimation of Uranium Deposits Based on Multiple Interpolation Methods. *Processes, 10 (1),* 67. https://doi.org/10.3390/pr10010067
21. Jalloh, A. B., Kyuro, S., Jalloh, Y., Barrie, A. K. (2016). Integrating artificial neural networks and geostatistics for optimum 3D geological block modeling in mineral reserve estimation: A case study. *International Journal of Mining Science and Technology, 26 (4),* 581–585. https://doi.org/10.1016/j.ijmst.2016.05.008
22. Zerzour, O., Gadri, L., Hadji, R., Mebrouk, F., Hamed, Y. (2020). Semi-variograms and kriging techniques in iron ore reserve categorization: application at Jebel Wenza deposit. *Arabian Journal of Geosciences, 13 (16).* https://doi.org/10.1007/s12517-020-05858-x
23. Smith, R., Faramarzi, F., Poblete, C. (2022). Strategic and Tactical Mine Planning Considering Value Chain Performance for Maximised Profitability. *IMPC Asia-Pacific 2022 Melbourne.*
24. Al Habib, N., Ben-Awuah, E., Askari-Nasab, H. (2023). Review of recent developments in short-term mine planning and IPCC with a research agenda. *Mining Technology: Transactions of the Institutions of Mining and Metallurgy, 132 (3),* 179–201. https://doi.org/10.1080/25726668.2023.2218170
25. Van Greunen, G. (2014). *Crafting and executing: an operational strategic plan for styldrift mine technical services.* Stellenbosch: Stellenbosch University. Available at: http://scholar.sun.ac.za

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ADDITIONAL RESEARCH INTO ARSENIC (III) EFFECTIVE CATALYTIC OXIDATION IN AN AQUEOUS SOLUTION ON A NEW CALCIUM DOPED ACTIVE MANGANESE DIOXIDE IN A FLOW COLUMN

pages 15–21

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In many places in the world, groundwater contains arsenic compounds. To purify water containing arsenic effectively, arsenic (III) compounds must be oxidised. The subject of this study is oxidation of arsenic (III) compounds in an aqueous solution in a flow column mode.

The industrial arsenic oxidation technology involving aggressive oxidising agents such as chlorine or ozone, which is used most commonly today, has a number of serious disadvantages. The most problematic include extremely high risks for human health and the environment, the process cost and overall complexity. Catalytic oxidation of arsenic (III) compounds with atmospheric oxygen is an alternative that is free from the above disadvantages. Previously, the author studied the process of effective catalytic oxidation of arsenic (III) on the new active manganese dioxide (NADM) he had synthesised.

Later, however, it turned out that NADM has a significant drawback: during prolonged flow column stops, its catalytic activity drops sharply. This work proposes both a theoretical justification for and a solution to this problem. A new calcium-doped active manganese dioxide NADM-Ca0.5 was synthesised. It was shown that NADM-Ca0.5 demonstrates high catalytic activity towards arsenic (III). The fact that flow column long stops do not affect its catalytic activity was also experimentally confirmed. On the basis of the study results, some theoretical aspects are also discussed of the mechanism for catalytic oxidation of arsenic (III) with oxygen on active manganese dioxide in an aqueous solution.

For successful industrial implementation of the technology for catalytic oxidation of arsenic (III) compounds on NADM-Ca0.5, experimental work on pilot plants in the field is required and further laboratory research is needed in order to develop a detailed theoretical basis for the mechanism of catalytic oxidation of arsenic in aqueous solutions.

The results of this work are of interest for both industrial companies specialising in water purification from arsenic compounds, and scientists and researchers studying catalytic oxidation of arsenic (III), as well as heterogeneous catalytic oxidation with oxygen in general.

Keywords: groundwater, water purification from arsenic, arsenic (III) oxidation, arsenic (III) oxidation catalysts, arsenic sorption.

References

1. Shaji, E., Santosh, M., Sarath, K. V., Prakash, P., Deepchand, V., Divya, B. V. (2021). Arsenic contamination of groundwater: A global synopsis with focus on the Indian Peninsula. *Geoscience Frontiers, 12 (3),* 101079. https://doi.org/10.1016/j.gsf.2020.08.015
2. Rajakovic, L., Rajakovic-Ognjanovic, V. (2018). Arsenic in Water: Determination and Removal. *Arsenic – Analytical and Toxicological Studies.* https://doi.org/10.5772/intechopen.75531
3. Hering, J. G., Katsoyiannis, I. A., Theoduloz, G. A., Berg, M., Hug, S. J. (2017). Arsenic Removal from Drinking Water: Experiences with Technologies and Constraints in Practice. *Journal of Environmental Engineering, 143 (5).* https://doi.org/10.1061/(asce)ee.1943-7870.0001225
4. Ghurye, G., Clifford, D. (2004). As(III) oxidation using chemical and solid-phase oxidants. *Journal AWWA, 96 (1),* 84–96. https://doi.org/10.1002/j.1551-8833.2004.tb10536.x
5. Zhang, W., Singh, P., Issa, T. B. (2011). Arsenic(III) Remediation from Contaminated Water by Oxidation and Fe/Al Co-Precipitation. *Journal of Water Resource and Protection, 3 (9),* 655–660. https://doi.org/10.4236/jwarp.2011.39075
6. Ghurye, G., Clifford, D. (2001). *Laboratory study on the oxidation of Arsenic III to Arsenic.* University of Houston.
7. Pokhrel, R., Goetz, M. K., Shaner, S. E., Wu, X., Stahl, S. S. (2015). The «Best Catalyst» for Water Oxidation Depends on the Oxidation Method Employed: A Case Study of Manganese Oxides. *Journal of the American Chemical Society, 137 (26),* 8384–8387. https://doi.org/10.1021/jacs.5b05093
8. Abower, D. (2024). Research into arsenic (III) effective catalytic oxidation in an aqueous solution on a new active manganese dioxide in a flow column. *Technology Audit and Production Reserves, 1 (3 (75)),* 15–23. https://doi.org/10.15587/2706-5448.2024.298969
9. Kariakin, Iu. V. (1947). *Chistye khimicheskie reaktivy.* GNTIKhL, 574.
10. Murray, J. W. (1974). The surface chemistry of hydrous manganese dioxide. *Journal of Colloid and Interface Science, 46 (3),* 357–371. https://doi.org/10.1016/0021-9797(74)90045-9
11. Feistel, U., Otter, P., Kunz, S., Grischek, T., Feller, J. (2016). Field tests of a small pilot plant for the removal of arsenic in groundwater using coagulation and filtering. *Journal of Water Process Engineering, 14,* 77–85. https://doi.org/10.1016/j.jwpe.2016.10.006
12. Johnston, R., Heijnen, H. *Safe Water Technology for Arsenic Removal Environmental Health Advisor.* Bangladesh. Johnston and Heijnen: Safe Water Technology for Arsenic Removal
13. Oscarson, D. W., Huang, P. M., Defosse, C., Herbillon, A. (1981). Oxidative power of Mn(IV) and Fe(III) oxides with respect to As(III) in terrestrial and aquatic environments. *Nature, 291 (5810),* 50–51. https://doi.org/10.1038/291050a0

14. Tran, L. (2017). *Arsenic removal using manganese oxide for arsenic oxidation process. Case study – Skovby waterworks*. Denmark Bachelor's thesis Environmental Engineering.

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STUDY OF TECHNOLOGICAL ASPECTS OF MANUFACTURE OF POLYMER COMPOSITE MATERIAL BY CENTRIFUGAL FIBER FORMING METHOD

pages 22–27

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The object of the study is the technological aspects of manufacturing the hesperidin polymer composite material by the method of centrifugal fiber formation. This method is considered the basis of a relatively new and cost-effective way of producing solid dispersion systems. Using the centrifugal molding method, it is possible to obtain highly soluble forms of active pharmaceutical ingredients in the form of fibers of various sizes using a wide range of polymeric materials with high speed and low cost due to simple equipment. Due to the innovative design of the centrifugal fiber formation method, it was chosen for the development of solid dispersion systems of the bioflavonoid hesperidin, which has a wide range of different pharmacological properties, but low bioavailability.

Solid dispersed systems of hesperidin by the method of centrifugal fiber formation were produced on the basis of a pharmaceutically acceptable polymeric carrier of polyvinylpyrrolidone and mannitol. For the obtained solid dispersed systems, such basic pharmaco-technological characteristics as loss in mass during drying, bulk volume, bulk volume after shrinkage, bulk density, bulk density after shrinkage, compressibility index, Gaussner coefficient were determined.

Comprehensive tests of the stability of the studied samples of the solid dispersion system of hesperidin were carried out under the conditions of accelerated tests for 6 months. According to the obtained results, it was established that the developed polymer composite material is stable in the studied conditions, and its conditional shelf life is 2 years.

A technological scheme for the production of the hesperidin polymer composite material in the form of solid dispersed systems by the method of centrifugal fiber formation has been developed. In particular, the technological process is described step by step and the critical indicators of quality control of the obtained composite material are determined. The proposed technology can be implemented in modern chemical and pharmaceutical industries. This will contribute to the expansion of the market of highly effective socially oriented medicines.

Keywords: hesperidin, solid dispersion system, polymer, centrifugal formation of fibers, polymer composite material.

References

1. Li, J., Yu, F., Chen, Y., Oupický, D. (2015). Polymeric drugs: Advances in the development of pharmacologically active polymers. *Journal of Controlled Release, 219*, 369–382. https://doi.org/10.1016/j.jconrel.2015.09.043
2. Adams, J. S., Sutar, Y., Dhoble, S., Maiti, C., Hanjankar, S. N., Das, R. et al. (2024). Pharmaceutical and biomedical polymers: Basics, modifications, and applications. *Polymers for Pharmaceutical and Biomedical Applications*, 1–86. https://doi.org/10.1016/b978-0-323-95496-9.00001-6
3. Nair, A. R., Lakshman, Y. D., Anand, V. S. K., Sree, K. S. N., Bhat, K., Dengale, S. J. (2020). Overview of Extensively Employed Polymeric Carriers in Solid Dispersion Technology. *AAPS PharmSciTech, 21 (8)*. https://doi.org/10.1208/s12249-020-01849-z
4. Malkawi, R., Malkawi, W. I., Al-Mahmoud, Y., Tawalbeh, J. (2022). Current Trends on Solid Dispersions: Past, Present, and Future. *Advances in Pharmacological and Pharmaceutical Sciences, 2022*, 1–17. https://doi.org/10.1155/2022/5916013
5. Tran, P., Pyo, Y.-C., Kim, D.-H., Lee, S.-E., Kim, J.-K., Park, J.-S. (2019). Overview of the Manufacturing Methods of Solid Dispersion Technology for Improving the Solubility of Poorly Water-Soluble Drugs and Application to Anticancer Drugs. *Pharmaceutics, 11 (3),* 132. https://doi.org/10.3390/pharmaceutics11030132
6. Satish, S., Priya, R. (2022). A mini review on centrifugal spinning technique for production of nanofibers and its applications in drug delivery. *Journal of Medical Pharmaceutical and Allied Sciences, 11 (1),* 4349–4352. https://doi.org/10.55522/jmpas.v11i1.2176
7. Zhang, X., Lu, Y. (2014). Centrifugal Spinning: An Alternative Approach to Fabricate Nanofibers at High Speed and Low Cost. *Polymer Reviews, 54 (4),* 677–701. https://doi.org/10.1080/15583724.2014.935858
8. Farhaj, S., Conway, B. R., Ghori, M. U. (2023). Nanofibres in Drug Delivery Applications. *Fibers, 11 (2),* 21. https://doi.org/10.3390/fib11020021
9. Marano, S., Barker, S. A., Raimi-Abraham, B. T., Missaghi, S., Rajabi-Siahboomi, A., Craig, D. Q. M. (2016). Development of micro-fibrous solid dispersions of poorly water-soluble drugs in sucrose using temperature-controlled centrifugal spinning. *European Journal of Pharmaceutics and Biopharmaceutics, 103,* 84–94. https://doi.org/10.1016/j.ejpb.2016.03.021
10. Nasir, S., Hussain, A., Abbas, N., Bukhari, N. I., Hussain, F., Arshad, M. S. (2021). Improved bioavailability of oxcarbazepine, a BCS class II drug by centrifugal melt spinning: In-vitro and in-vivo implications. *International Journal of Pharmaceutics, 604,* 120775. https://doi.org/10.1016/j.ijpharm.2021.120775
11. Hussain, A., Hussain, F., Arshad, M. S., Abbas, N., Nasir, S., Mudassir, J. et al. (2021). Ibuprofen-loaded centrifugally spun microfibers for quick relief of inflammation in rats. *Drug Development and Industrial Pharmacy, 47 (11),* 1786–1793. https://doi.org/10.1080/03639045.2022.2059500
12. Priya, R., Satish, S. (2023). Centrifugal Melt Spun Microfi brous Solid Dispersion of Diclofenac Sodium with Enhanced Solubility. *International journal of pharmaceutical quality assurance, 14 (1),* 165–170. https://doi.org/10.25258/ijpqa.14.1.28
13. Alfassam, H. A., Booq, R. Y., Almousained, M. M., Alajmi, A. M., Elfaky, M. A., Shaik, R. A. et al. (2024). Fabrication and evaluation of centrifugal spun Miconazole-loaded sugar-based fibers. *Journal of Drug Delivery Science and Technology, 98,* 105872. https://doi.org/10.1016/j.jddst.2024.105872
14. Choi, S.-S., Lee, S.-H., Lee, K.-A. (2022). A Comparative Study of Hesperetin, Hesperidin and Hesperidin Glucoside: Antioxidant, Anti-Inflammatory, and Antibacterial Activities In Vitro. *Antioxidants, 11 (8),* 1618. https://doi.org/10.3390/antiox11081618
15. Donia, T., Dabbour, N. M., Loutfy, S. A.; Xiao, J. (Ed.) (2023). Hesperidin: Advances on Resources, Biosynthesis Pathway, Bioavailability, Bioactivity, and Pharmacology. *Handbook of Dietary Flavonoids.* Cham: Springer, 1–55. https://doi.org/10.1007/978-3-030-94753-8_28-1
16. *European Pharmacopoeia 9.0 Volume* 1. (2018). Strasbourg: Council of Europe.
17. Heorhiievskyi, V., Liapunov, M., Bezuhla, O. et al. (2004). *Nastanova z yakosti. Likarski zasoby. Vyprobuvannia stabilnosti.* Nastanova 42-3.3.2004. Ministerstvo okhorony zdorovia Ukrainy. Kyiv: Morion, 60.

18. Lisovyi, V., Bessarabov, V., Goy, A., Kostiuk, V. (2024). Spectrophotometric method for determining the assay of hesperidin in the composition of polymer composite material obtained by centrifugal fiber formation. *Herald of Khmelnytskyi National University. Technical Sciences, 335 (3 (1)),* 135–141. https://doi.org/10.31891/2307-5732-2024-335-3-19
19. Kurakula, M., Rao, G. S. N. K. (2020). Pharmaceutical assessment of polyvinylpyrrolidone (PVP): As excipient from conventional to controlled delivery systems with a spotlight on COVID-19 inhibition. *Journal of Drug Delivery Science and Technology, 60,* 102046. https://doi.org/10.1016/j.jddst.2020.102046
20. Hureieva, S. M., Kondratova, Yu. A. (2016). Vyvchennia stabilnosti likarskoho zasobu Antral, tabletky, vkryti obolonkoiu. *Farmatsevtychnyi zhurnal, 2,* 70–76.

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DETERMINATION OF THE TEMPERATURE OF MINERAL FERTILISER GRANULES AFTER CONTACT WITH THE AIR IN A GRANULATION TOWER

pages 28–32

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The object of research is the process of cooling mineral fertilizer granules in a granulation tower. The main problem that was solved was the analysis of the temperature mode of cooling the granules to increase their strength and quality, as well as to reduce the probability of their destruction during storage and transportation.

The design of a rotating vibrating granulator (RVG) and a mathematical model for calculating the temperature of granules and air at different stages of the granulation process are presented. Reynolds, Peclet and Prandtl criteria are used to describe hydrodynamic and thermodynamic processes.

In the course of the work, a calculation model and the possibility of predicting the final temperature of mineral fertilizer granules were created, which allows to avoid negative consequences, such as a decrease in the strength of the granules and their destruction during shipment, transportation and introduction into the soil. Improving the technological performance of the granulation tower, in particular the temperature regimes of granule cooling, contributes to the improvement of product quality. The calculation model allows to adjust the process parameters to ensure the formation of granules with specified properties that meet modern requirements for the monodisperse composition of mineral fertilizer granules.

Results were obtained that show the influence of hydrodynamic and thermodynamic factors on the process of cooling and crystallization of granules. This is due to the use of a rotating vibrating granulator, which ensures uniform distribution of liquid droplets across the cross section of the tower and their effective cooling due to contact with the air flow.

The results can be used in practice to improve the operation of granulation towers in the production of mineral fertilizers, which allows to improve the quality of products and improve their storage and use. Compared to similar methods, the use of the proposed models provides increased strength and uniformity of granules, which are key advantages in conditions of large-scale production of fertilizers.

Keywords: granulation tower, heat transfer coefficient, rotating vibrating granulator, mineral fertilizers, thermodynamic processes, hydrodynamic parameters.

References

1. Skydanenko, M. S. (2014). *Hidromekhanichni pokaznyky prystroiv dlia otrymannia monodyspersnykh krapel ta hranu*l. PhD dissertation.
2. Islamova, A. (2018). Experimental determination of the heat transfer coefficient during evaporation and boiling of thin liquid film. *MATEC Web of Conferences, 194,* 01022. https://doi.org/10.1051/matecconf/201819401022
3. Vossel, T., Wolff, N., Pustal, B., Bührig-Polaczek, A., Ahmadein, M. (2021). Heat Transfer Coefficient Determination in a Gravity Die Casting Process with Local Air Gap Formation and Contact Pressure Using Experimental Evaluation and Numerical Simulation. *International Journal of Metalcasting, 16 (2),* 595–612. https://doi.org/10.1007/s40962-021-00663-y
4. Moreira, T. A., Colmanetti, A. R. A., Tibiriçá, C. B. (2019). Heat transfer coefficient: a review of measurement techniques. *Journal of the Brazilian Society of Mechanical Sciences and Engineering, 41 (6).* https://doi.org/10.1007/s40430-019-1763-2
5. Wu, C., Xu, W., Wan, S., Luo, C., Lin, Z., Jiang, X. (2022). Determination of Heat Transfer Coefficient by Inverse Analyzing for Selective Laser Melting (SLM) of AlSi10Mg. *Crystals, 12 (9),* 1309. https://doi.org/10.3390/cryst12091309
6. Petrich, C., Arntsen, M., Dayan, H., Nilsen, R. (2013). Heat Transfer in a Bed of Dry Iron Ore Pellets. *ISIJ International, 53 (4),* 723–725. https://doi.org/10.2355/isijinternational.53.723
7. Chung, C.-H., Yang, K.-S., Chien, K.-H., Jeng, M.-S., Lee, M.-T. (2014). Heat Transfer Characteristics in High Power LED Packaging. *Smart Science, 2 (1),* 1–6. https://doi.org/10.1080/23080477.2014.11665596
8. Yurchenko, O., Sklabinskyi, V., Ochowiak, M., Ostroha, R., Gusak, O. (2022). Rational Choice of a Basket for the Rotational Vibropriller. *Journal of Engineering Sciences, 9 (1),* F16–F20. https://doi.org/10.21272/jes.2022.9(1).f3
9. Coulson, J. M., Richardson, J. F. (1999). *Chemical Engineering.* Vol. 1. Elsevier.
10. Chepurnyi, M. M., Tkachenko, S. Y. (2004). *Osnovy tekhnichnoi termodynamiky*. Vinnytsia: Podillia-2000, 358.

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ANALYZING AND DISTRIBUTION OF POLYCHLORINATED BIPHENYLS (PCBs) IN SEDIMENTS ALONG SHATT AL-ARAB ESTUARY, IRAQ

pages 33–38

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The object of this research is the polychlorinated biphenyls (PCBs) in sediments along Shatt Al-Arab Estuary, Iraq. The study examines the problem of river PCB pollution. PCB effects on humans include cancer, impaired reproduction, neuro-developmental effects in infants, immunotoxicity and endocrine disruption. PCBs lead to liver damage and stimulate changes in the DNA sequence. The Shatt Al-Arab Estuary is formed in southern Iraq near Al-Qurna city after the confluence of the Tigris and Euphrates Rivers. The Shatt Al-Arab Estuary region is shared between Iraq and Iran. The Estuary receives pollutants when it is passing during Basrah City regions, due to industrial, agricultural and human activities which discharge the pollutants to the Estuary without treatment.

The concentrations of Σ13 PCBs compound in sediment samples were determined and analyzed at each site by using gas chromatography-mass spectrometry (GC-MS, Agilent). Six sites were chosen along Shatt Al-Arab Estuary. They are Al-Qurna (S1), Al-Deer (S2), Al-Qarma (S3), Al-Ashar (S4), Abi Al-Khasib (S5) and Al-Fao (S6), at Basrah city, south of Iraq. Sediment samples were collected seasonally, starting from Autumn season on September 2019 to summer season on July 2020. The Σ13 (PCB-18, PCB-29, PCB-31, PCB-28, PCB-44, PCB-52, PCB-101, PCB-141, PCB-149, PCB-138, PCB-153, PCB-189, and PCB-194) concentrations at the sediment samples ranged from 4.48 ng/g in Al-Deer site during summer season to 27.75 ng/g in Al-Ashar site during winter season for all selected sites. The Al-Deer site were found to have the lowest mean of PCBs its 0.345 ng/g and Al-Ashar site were found to have the highest mean of PCBs its 2.135 ng/g. PCBs concentrations in sediment samples during autumn, winter, spring and summer seasons ranged from 7.75 to 21.68 ng/g, 16.25 to 27.75 ng/g, 7.28 to 22.01 ng/g and 4.48 to 14.41 ng/g, respectively. The congener distribution patterns in these samples indicate the dominance highly chlorinated congeners (tri- and hexa-PCBs) in comparison with remaining others PCBs congeners. This project is the first of its kind in Basrah and all Iraq that reports PCB concentrations in the region and is considered a baseline study and can be used for subsequent studies.

Keywords: sediments, Shatt Al-Arab Estuary, polychlorinated biphenyls, PCBs, seasonal variation, gas chromatography-mass spectrometry.

References

1. Wang, Y., Luo, C.-L., Li, J., Yin, H., Li, X.-D., Zhang, G. (2011). Characterization and risk assessment of polychlorinated biphenyls in soils and vegetations near an electronic waste recycling site, South China. *Chemosphere, 85 (3),* 344–350. https://doi.org/10.1016/j.chemosphere.2011.06.096
2. Cocco, E., Guignard, C., Hoffmann, L., Bohn, T. (2011). Rapid analysis of polychlorinated biphenyls in fish by pressurised liquid extraction with in-cell cleanup and GC-MS. *International Journal of Environmental Analytical Chemistry, 91 (4),* 333–347. https://doi.org/10.1080/03067319.2010.496048
3. Kucklick, J. R., Baker, J. E. (1998). Organochlorines in Lake Superior's Food Web. *Environmental Science & Technology, 32 (9),* 1192–1198. https://doi.org/10.1021/es970794q
4. Jiang, J.-J., Lee, C.-L., Fang, M.-D., Ko, F.-C., Baker, J. E. (2011). Polybrominated diphenyl ethers and polychlorinated biphenyls in sediments of southwest Taiwan: Regional characteristics and potential sources. *Marine Pollution Bulletin, 62 (4),* 815–823. https://doi.org/10.1016/j.marpolbul.2010.12.019
5. Li, Q., Luo, Z., Yan, C., Zhang, X. (2011). Assessment of Polychlorinated Biphenyls Contamination in Sediment and Organism from Xiamen Offshore Area, China. *Bulletin of Environmental Contamination and Toxicology, 87 (4),* 372–376. https://doi.org/10.1007/s00128-011-0385-x
6. Barakat, A. O., Khairy, M., Aukaily, I. (2013). Persistent organochlorine pesticide and PCB residues in surface sediments of Lake Qarun, a protected area of Egypt. *Chemosphere, 90 (9),* 2467–2476. https://doi.org/10.1016/j.chemosphere.2012.11.012
7. Klaren, W. D., Gadupudi, G. S., Wels, B., Simmons, D. L., Olivier, A. K., Robertson, L. W. (2015). Progression of micronutrient alteration and hepatotoxicity following acute PCB126 exposure. *Toxicology, 338,* 1–7. https://doi.org/10.1016/j.tox.2015.09.004
8. Ludewig, G., Robertson, L. W. (2013). Polychlorinated biphenyls (PCBs) as initiating agents in hepatocellular carcinoma. *Cancer Letters, 334 (1),* 46–55. https://doi.org/10.1016/j.canlet.2012.11.041
9. Frame, G. M., Robertson, L. W., Hansen, L. G. (2001). The current state-of-the-art of comprehensive, quantitative, congener-specific PCB analysis, and what we now know about the distributions of individual congeners in commercial Aroclor mixtures. *PCBs: Recent Advances in Environmental Toxicology and Health Effects,* 3–9.
10. Mai, B., Zeng, E. Y., Luo, X., Yang, Q., Zhang, G., Li, X., Sheng, G., and Fu, J. (2004). Abundances, Depositional Fluxes, and Homologue Patterns of Polychlorinated Biphenyls in Dated Sediment Cores from the Pearl River Delta, China. *Environmental Science & Technology, 39 (1),* 49–56. https://doi.org/10.1021/es049015d
11. *PCB Transformers and Capacitors From Management to Reclassification and Disposal* (2002). United Nation Environment Programme UNEP Chemicals.
12. Rahuman, M., Pistone, L., Trifirò, F., Miertus, S. (2000). Destruction technologies for polychlorinated biphenyls (PCBs). *Proceedings of Expert Group Meetings on POPs and Pesticides Contamination, 16 (6),* 405–423.
13. Al-Saad, H. T., Alhello, A. A., Al-Kazaeh, D. K., Al-Hello, M. A., Hassan, W. F., Mahdi, S. (2015). Analysis of Water Quality Using Physico-Chemical Parameters in the Shatt AL-Arab Estuary, Iraq. *International Journal of Marine Science.* https://doi.org/10.5376/ijms.2015.05.0049
14. *Standard method for the examination of water and wastewater* (2005). APHA, American Public Health Association. Washington, 1193.
15. Aganbi, E., Iwegbue, C. M. A., Martincigh, B. S. (2019). Concentrations and risks of polychlorinated biphenyls (PCBs) in transformer oils and the environment of a power plant in the Niger Delta, Nigeria. *Toxicology Reports, 6,* 933–939. https://doi.org/10.1016/j.toxrep.2019.08.008
16. Al-Khatib, F. M. H. (1998). *Distribution of hydrocarbons compound and their sources in sediment cores from Shatt Al-Arab Estuary and NW Arabian Gulf*. M.Sc. thesis. University of Basrah.
17. Zhou, J. L., Hong, H., Zhang, Z., Maskaoui, K., Chen, W. (2000). Multi-phase distribution of organic micropollutants in Xiamen Harbour, China. *Water Research, 34 (7),* 2132–2150. https://doi.org/10.1016/s0043-1354(99)00360-7
18. Arfaeinia, H., Asadgol, Z., Ahmadi, E., Seifi, M., Moradi, M., Dobaradaran, S. (2017). Characteristics, distribution and sources of polychlorinated biphenyls (PCBs) in coastal sediments from the heavily industrialized area of Asalouyeh, Iran. *Water Science and Technology, 76 (12),* 3340–3350. https://doi.org/10.2166/wst.2017.500
19. Gómez-Gutiérrez, A., Garnacho, E., Bayona, J. M., Albaigés, J. (2007). Screening ecological risk assessment of persistent organic pollutants in Mediterranean sea sediments. *Environment International, 33 (7),* 867–876. https://doi.org/10.1016/j.envint.2007.04.002
20. Abdel-Dayem, S. (1994). Water quality issues in Egypt. *Proceedings of the Italian-Egyptian Study-Days on the Environment (IESDE'94),* 81–92.
21. Konat, J., Kowalewska, G. (2001). Polychlorinated biphenyls (PCBs) in sediments of the southern Baltic Sea – trends and fate. *The Science of the Total Environment, 280 (1-3),* 1–15. https://doi.org/10.1016/s0048-9697(01)00785-9
22. Al-Hejuje, M. M. (2014). *Application of water quality and pollution indices to evaluate the water and sediments status in the middle part of Shatt Al-Arab River.* PhD Thesis. University of Basrah.

23. Johnson, G. W., Hamilton, M. C., Forensics, E. (2006). *Polychlorinated Biphenyl.* Environmental Forensics.
24. Gao, J., Shi, H., Dai, Z., Mei, X., Zong, H., Yang, H. et al. (2018). Linkages between the spatial toxicity of sediments and sediment dynamics in the Yangtze River Estuary and neighboring East China Sea. *Environmental Pollution, 233,* 1138–1146. https://doi.org/10.1016/j.envpol.2017.10.023
25. Sakai, N., Dayana, E., Abu Bakar, A., Yoneda, M., Nik Sulaiman, N. M., Ali Mohd, M. (2016). Occurrence, distribution, and dechlorination of polychlorinated biphenyls and health risk assessment in Selangor River basin. *Environmental Monitoring and Assessment, 188 (10).* https://doi.org/10.1007/s10661-016-5595-6
26. Lyons, B. P., Barber, J. L., Rumney, H. S., Bolam, T. P. C., Bersuder, P., Law, R. J. et al. (2015). Baseline survey of marine sediments collected from the State of Kuwait: PAHs, PCBs, brominated flame retardants and metal contamination. *Marine Pollution Bulletin, 100 (2),* 629–636. https://doi.org/10.1016/j.marpolbul.2015.08.014
27. El-Aziz El-Maradny, A. A., Turki, A. J., Shaban, Y. A., Sultan, K. M. (2015). Levels and Distribution of Polychlorinated Biphenyls in Jeddah Coastal Sediments, Red Sea, Saudi Arabia. *Journal of the Chemical Society of Pakistan, 37 (3),* 599–611.
28. Hassan, J., NejatKhah Manavi, P., Darabi, E. (2013). Polychlorinated biphenyls hot and cold seasons distribution in see water, sediment, and fish samples in the Khour-e-Mousa (Mah-Shahr), Iran. *Chemosphere, 90 (9),* 2477–2482. https://doi.org/10.1016/j.chemosphere.2012.11.006
29. El-Kady, A. A., Abdel-Wahhab, M. A., Henkelmann, B., Belal, M. H., Morsi, M. K. S., Galal, S. M., Schramm, K.-W. (2007). Polychlorinated biphenyl, polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran residues in sediments and fish of the River Nile in the Cairo region. *Chemosphere, 68 (9),* 1660–1668. https://doi.org/10.1016/j.chemosphere.2007.03.066
30. Barhoumi, B., LeMenach, K., Dévier, M.-H., El megdiche, Y., Hammami, B., Ameur, W. B. et al. (2013). Distribution and ecological risk of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in surface sediments from the Bizerte lagoon, Tunisia. *Environmental Science and Pollution Research, 21 (10),* 6290–6302. https://doi.org/10.1007/s11356-013-1709-7
31. Iwegbue, C. (2016). Distribution and ecological risks of polychlorinated biphenyls (PCBs) in surface sediment of the Forcados River, Niger Delta, Nigeria. *African Journal of Aquatic Science, 41 (1),* 51–56. https://doi.org/10.2989/16085914.2016.1138926
32. Zhang, R., Zhang, F., Zhang, T., Yan, H., Shao, W., Zhou, L., Tong, H. (2014). Historical sediment record and distribution of polychlorinated biphenyls (PCBs) in sediments from tidal flats of Haizhou Bay, China. *Marine Pollution Bulletin, 89 (1-2),* 487–493. https://doi.org/10.1016/j.marpolbul.2014.09.001
33. Bazzanti, M., Chiavarini, S., Cremisini, C., Soldati, P. (1997). Distribution of PCB congeners in aquatic ecosystems: A case study. *Environment International, 23 (6),* 799–813. https://doi.org/10.1016/s0160-4120(97)00092-5
34. Wenning, R. J., Bonnevie, N. L., Huntley, S. L. (1994). Accumulation of metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons in sediments from the lower Passaic River, New Jersey. *Archives of Environmental Contamination and Toxicology, 27 (1),* 64–81. https://doi.org/10.1007/bf00203890
35. Ssebugere, P., Sillanpää, M., Kiremire, B. T., Kasozi, G. N., Wang, P., Sojinu, S. O. et al. (2014). Polychlorinated biphenyls and hexachlorocyclohexanes in sediments and fish species from the Napoleon Gulf of Lake Victoria, Uganda. *Science of The Total Environment, 481,* 55–60. https://doi.org/10.1016/j.scitotenv.2014.02.039

FOOD PRODUCTION TECHNOLOGY

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CONSIDERATION OF TECHNOLOGICAL AND SAFETY ASPECTS OF USING ZINC OXIDE NANOPARTICLES FOR INTENSIFYING WHEY FERMENTATION

pages 39–45

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The study is dedicated to using zinc oxide nanoparticles (ZnO) to intensify the fermentation of whey, an important resource in the food industry. Traditional methods of whey fermentation take a lot of time and require significant resources, reducing their economic efficiency. This study found that the addition of ZnO nanoparticles significantly accelerates the fermentation process. Treating whey with the electro-spark method for 60 seconds allowed achieving the necessary acidity level (160±10 °T) in 18 hours, almost twice as fast as traditional methods, which take up to 36 hours. ZnO nanoparticles also improve the activity of lactic acid bacteria and increase the bactericidal ability of macrophages, which contributes to the overall efficiency of the fermentation process.

The use of ZnO nanoparticles in whey production can significantly improve the efficiency of the technological process, reducing fermentation time and improving the quality of the final product. This opens up new prospects for medium and small enterprises looking to improve the economic efficiency of their operations.

In addition to accelerating fermentation, ZnO nanoparticles have additional advantages in terms of product safety and quality. The study showed that ZnO nanoparticles enhance the antioxidant properties of fermented products, which is important for maintaining their freshness and nutritional value. The high reactivity of ZnO nanoparticles allows them to interact with bacterial membrane receptors, increasing their metabolic activity and resistance to external factors.

Thus, the study demonstrates the significant potential of using ZnO nanoparticles to intensify the whey fermentation process, contributing to more efficient production of food products and ensuring their high quality. This is especially important in modern conditions of limited resources and growing demands for economic efficiency and food safety. The introduction of ZnO nanoparticles into production processes can be a key step in improving fermentation technologies and increasing the competitiveness of food products in the market.

Keywords: whey, lactic acid, zinc oxide nanoparticles, whey fermentation, intensification, cytotoxicity of nano-ZnO.

References

1. *Statystychni dani vyrobnytstva promyslovoi produktsii za vydamy za 2020 i 2021 roky.* Available at: http://www.ukrstat.gov.ua/ Last accessed: 10.06.2024
2. Pyroh, T. P. (2010). *Zahalna mikrobiolohiia*. Kyiv: NUKhT, 632.
3. Stehlik-Tomas, V., Zetic, V. G., Stanzer, D., Grba, S., Vahcic, N. (2004) Zinc, Copper and Manganese Enrichment in Yeast Saccharomyces cerevisiae. *Food Technology and Biotechnology, 42 (2),* 115–120.
4. Meng, Y., Liang, Z., Yi, M., Tan, Y., Li, Z., Du, P. et al. (2022). Enrichment of zinc in Lactobacillus plantarum DNZ-4: Impact on its characteristics, metabolites and antioxidant activity. *LWT, 153,* 112462. https://doi.org/10.1016/j.lwt.2021.112462
5. Karputina, M. V., Romanova, Z. M., Sydor, V. M., Karputina, D. D. (2012) Suchasni sposoby aktyvatsii protsesiv rozmnozhennia ta fermentatsii pyvovarnykh drizhdzhiv. *Obladnannia ta tekhnolohii kharchovykh vyrobnytstv, 28,* 125–130.
6. Koshova, V. M., Yazhlo, V. S., Kaplunenko, V. H., Ohorodnyk, Yu. I. (2015). Increase of fermentative activity of brewing yeast using zinc nanoaquachelate. *Eastern-European Journal of Enterprise Technologies, 4 (10 (76)),* 40–44. https://doi.org/10.15587/1729-4061.2015.47888
7. Kochubei-Lytvynenko, O., Chernyushok, O., Bilyk, O., Bondarenko, Y. (2019). Studying the effect of electrospark treatment of milk whey on the process of its fermentation and quality of thermoacid cheese. *Eastern-European Journal of Enterprise Technologies, 6 (11 (102)),* 33–40. https://doi.org/10.15587/1729-4061.2019.183712
8. Chasapis, C. T., Loutsidou, A. C., Spiliopoulou, C. A., Stefanidou, M. E. (2011). Zinc and human health: an update. *Archives of Toxicology, 86 (4),* 521–534. https://doi.org/10.1007/s00204-011-0775-1
9. González-Weller, D., Paz-Montelongo, S., Bethencourt-Barbuzano, E., Niebla-Canelo, D., Alejandro-Vega, S., Gutiérrez, Á. J. et al. (2023). Proteins and Minerals in Whey Protein Supplements. *Foods, 12 (11),* 2238. https://doi.org/10.3390/foods12112238
10. Chekman, I. S., Ulberh, Z. R., Rudenko, A. D. et al. (2013) Tsynk i nanotsynk: vlastyvosti, zastosuvannia u klinichnii praktytsi. *Ukrainskyi medychnyi chasopys, III/IV (2 (94)),* 42–47.
11. Jiang, J., Pi, J., Cai, J. (2018). The Advancing of Zinc Oxide Nanoparticles for Biomedical Applications. *Bioinorganic Chemistry and Applications, 2018*, 1–18. https://doi.org/10.1155/2018/1062562
12. Kochubei-Lytvynenko, O. V., Lopatko, K. H. (2021) Nanobiotekhnolohichni osnovy spriamovanoho zbahachennia molochnoi syrovatky mineralnymy elementamy. *Naukovi pratsi NUKhT, 5,* 134–148.
13. Lopatko, K. H., Aftandiliants, Ye. H., Zazymko, O. V., Trach, V. V. (2016). *Fizyka, syntez ta biolohichna funktsionalnist nanorozmirnykh obiektiv.* Kyiv: Vyd-vo NUBiP Ukrainy, 615.
14. Sharma, V., Anderson, D., Dhawan, A. (2012). Zinc oxide nanoparticles induce oxidative DNA damage and ROS-triggered mitochondria mediated apoptosis in human liver cells (HepG2). *Apoptosis, 17 (8),* 852–870. https://doi.org/10.1007/s10495-012-0705-6
15. Dmytrukha, N. M., Luhovskyi, S. P., Lahutina, O. S. (2015) Toksychnyi efekt nanochastynok oksydu zaliza na perytonealni makrofahy shchuriv. *Ukrainskyi zhurnal z problem medytsyny pratsi, 3,* 28–33.
16. Kharazian, B., Hadipour, N. L., Ejtehadi, M. R. (2016). Understanding the nanoparticle-protein corona complexes using computational and experimental methods. *The International Journal of Biochemistry & Cell Biology, 75,* 162–174. https://doi.org/10.1016/j.biocel.2016.02.008
17. Wahab, R., Siddiqui, M. A., Saquib, Q., Dwivedi, S., Ahmad, J., Musarrat, J. et al. (2014). ZnO nanoparticles induced oxidative stress and apoptosis in HepG2 and MCF-7 cancer cells and their antibacterial activity. *Colloids and Surfaces B: Biointerfaces, 117,* 267–276. https://doi.org/10.1016/j.colsurfb.2014.02.038

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STUDY OF ANTIOXIDANT PROPERTIES OF ORGANIC DRIED BLACK MULBERRY

pages 46–50

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The object of the study is black dried organic mulberry. The subject of research is the antioxidant properties of black dried organic mulberry. The research hypothesis is that due to its antioxidant properties, organic black mulberry can serve as a source for the production of food additives to slow down oxidation processes in fat-containing products.

The study investigated changes in the quality of the fat base for the production of flour confectionery products: butter with sesame oil in a ratio of 80:20 %. Black dried inorganic mulberry was used as a control sample. This made it possible to compare the inhibitory-stabilizing effect on lipids of organic and inorganic raw materials. On the 10th day of storage of the samples, the peroxide number in the fat with the addition of organic mulberry was 1.7 times lower than in the fat base without the addition of stabilizers. The peroxide number in the fat with organic mulberry added was 17.5 ½O mmol/kg. Primary oxidation in the sample with inorganic mulberry also occurred more slowly than in the sample without any additives. On the 10th day of storage, the amount of peroxides was 1.2 times less than the amount of peroxides in the fat base without the addition of mulberry. The fat acid value of black organic dried mulberry added on day 10 was 1.21 mn/KOH, with black inorganic dried mulberry added 1.80 mg/KOH. The sample without added antioxidants had an acid value of 2.12 mg/KOH. The content of ascorbic acid in black dried inorganic and organic mulberries does not differ significantly and is 10.78 and 10.49 mg/100 g, respectively. It has been proven that the content of polyphenolic compounds is 18.2 and 27.2 mg/100 g, respectively, in dried inorganic and organic black mulberries. It is their presence that explains the antioxidant properties of mulberry. Therefore, organic production affects the accumulation of polyphenolic compounds in plants. Polyphenolic compounds have antimicrobial properties, so their higher amount in organic raw materials is dictated by the fact that organic plants must independently fight against microbiological pests without the use of pesticides. Further research will be devoted to the creation of nutritional supplements based on organic black mulberry.

Keywords: black organic dried mulberry, peroxide number, acid number, ascorbic acid, polyphenolic content, antioxidant properties.

References

1. Jan, B., Parveen, R., Zahiruddin, S., Khan, M. U., Mohapatra, S., Ahmad, S. (2021). Nutritional constituents of mulberry and their potential applications in food and pharmaceuticals: A review. *Saudi Journal of Biological Sciences, 28 (7),* 3909–3921. https://doi.org/10.1016/j.sjbs.2021.03.056
2. Rohela, G. K., Shukla, P., Muttanna, Kumar, R., Chowdhury, S. R. (2020). Mulberry (*Morus spp.*): An ideal plant for sustainable development. *Trees, Forests and People, 2,* 100011. https://doi.org/10.1016/j.tfp.2020.100011
3. Gungor, N., Sengul, M. (2008). Antioxidant Activity, Total Phenolic Content and Selected Physicochemical Properties of White Mulberry (*Morus AlbaL.*) Fruits. *International Journal of Food Properties, 11 (1),* 44–52. https://doi.org/10.1080/10942910701558652

4. Sakthivel, N., Ravikumar, J., Mukund, V., Bindroo, B., Sivaprasad, B. (2024). Organic farming in mulberry: recent breakthrough. *Technical bulletin.*
5. Ercisli, S., Orhan, E. (2007). Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. *Food Chemistry, 103 (4),* 1380–1384. https://doi.org/10.1016/j.foodchem.2006.10.054
6. Aljane, F., Sdiri, N. (2016). Morphological, phytochemical and antioxidant characteristics of white (*Morus alba L.*), red (*Morus rubra L.*) and black (*Morus nigra L.*) mulberry fruits grown in arid regions of Tunisia. *Journal of new sciences, Agriculture and Biotechnology, 35 (1),* 1940–1947.
7. Bae, S.-H., Suh, H.-J. (2007). Antioxidant activities of five different mulberry cultivars in Korea. *LWT – Food Science and Technology, 40 (6),* 955–962. https://doi.org/10.1016/j.lwt.2006.06.007
8. Grajek, K., Wawro, A., Pieprzyk-Kokocha, D. (2015). Bioactivity of Morus Alba L. Extracts – An Overview. *International Journal of Pharmaceutical Sciences and Research, 6 (8),* 3110–3122.
9. Tkachenko, A. (2023). Comparative study of the antioxidant properties of organic and inorganic melissa. *Technology Audit and Production Reserves, 4 (3 (72)),* 19–23. https://doi.org/10.15587/2706-5448.2023.286687
10. Cruz-Carrión, Á., Ruiz de Azua, Ma. J., Muguerza, B., Mulero, M., Bravo, F. I., Arola-Arnal, A., Suarez, M. (2023). Organic vs. Non-Organic Plant-Based Foods – A Comparative Study on Phenolic Content and Antioxidant Capacity. *Plants, 12 (1),* 183. https://doi.org/10.3390/plants12010183
11. Syrokhman, I. V., Hyrka, O. I. (2008). Vplyv antyokysliuvachiv na zminu yakosti soievoi olii. *Naukovyi visnyk LNUVMBT imeni S. Z. Gzhytskoho, 10 (2 (37)),* 164–166.
12. Gensler, M., Rossmann, A., Schmidt, H.-L. (1995). Detection of Added L-Ascorbic Acid in Fruit Juices by Isotope Ratio Mass Spectrometry. *Journal of Agricultural and Food Chemistry, 43 (10),* 2662–2666. https://doi.org/10.1021/jf00058a020
13. Ibragc, S., Salihovic, M., Tahirovic, I., Toromanovic, J. (2014). Quantification of some phenolic acids in the leaves of *Melissa officinalis L.* from Turkey and Bosnia. *Bull Chem Tech Bosnia Herzegovina, 42,* 47–50.