Brief information about the project

Title	Investigation of the stability of black cumin seed oil and grape seed oil through the synergistic effect observed during co-supercritical CO_2 extraction
Relevance	Functional oils derived from grape seed and black cumin oils are of significant interest due to their rich composition and high biological activity. These oils contain essential unsaturated fatty acids, vitamins, and antioxidants. However, the impact of supercritical CO_2 extraction on their oxidative stability, as well as potential synergistic effects during co-extraction, remains insufficiently explored. Furthermore, the remaining pomace represents a promising feedstock for the production of activated carbons. Given the large-scale waste generated by the winemaking industry and the growing demand for environmentally friendly, zero-waste technologies, the development of efficient methods for obtaining both oils and activated carbons from remaining pomace is relevant from scientific, industrial, and ecological perspectives.
Goal	The project objective is to develop technology for joint supercritical CO_2 extraction of grape seed oil and black cumin oil to obtain functional oil with high oxidative stability and balanced fatty acid composition, also to produce effective activated carbons from the pomace of grape seeds and black cumin.
Tasks	To achieve the project's objective, the following tasks have been set: 1. Study the qualitative and quantitative composition of grape seeds and black cumin seeds; 2. Study the impact of joint SC-CO_2 modes (static, dynamic, and combined) on the qualitative and quantitative composition of GSO and BCO; 3. Investigate the influence of pressure, temperature in the extractor and separator on the qualitative and quantitative composition of GSO and BCO; 4. Assess the oxidative stability, fatty acid composition, and nutritional properties of the obtained functional oil; 5. Conduct a toxicological evaluation of the obtained functional oil; 6. Study the properties of activated carbon (sorption capacity for methylene blue, copper, and lead, pore size) obtained after oil removal; 7. Develop a zero-waste technological scheme for the production of functional oil and activated carbon.
Expected and Achieved Results	The results of this project will be presented in the form of scientific publications, specifically no fewer than two (2) articles in journals ranked within the top three quartiles by impact factor according to the Web of Science database, or with a CiteScore percentile of no less than 50 in the Scopus database. The results are intended to be published in journals such as Food Chemistry (97th percentile, Q1), Chemical Engineering and Processing (83rd percentile, Q2), or others of similar standing. Additionally, based on the obtained results, one PhD dissertation will be written and defended. A utility model patent will be filed with the Kazakhstan Patent Office. As a technological outcome, a functional oil with enhanced oxidative stability, a balanced fatty acid composition, and high antioxidant activity will be developed, owing to the synergistic effect observed during combined SC-CO_2 extraction. Activated

	carbons based on grape seed and black cumin residues will also be obtained, modified with urea and thiourea to achieve high sorption capacities. A toxicological assessment of the resulting functional oil (FO) will be conducted, including the determination of benzo(a)pyrene, erucic acid, and residual pesticide levels. The final result will be a zero-waste technology for obtaining functional oil by combined SC-CO_2 extraction from grape seeds (GS) and black cumin (BC), along with the production of modified activated carbons (AC). The resulting FO can be widely used in the food industry (for frying, salad dressings, as a natural preservative), the cosmetic industry (creams, cosmetic oils), and the pharmaceutical industry (capsules with functional oil, ointments) as a product rich in antioxidants and vitamins, with a balanced fatty acid profile and an extended shelf life. AC from GS and BC residues, modified with urea and thiourea, will be produced. These sorbents will be capable of removing heavy metals such as copper and lead from wastewater. Upon successful completion of the project, an application will be submitted for the Grant Funding competition for young scientists, with the aim of further commercializing the project through JSC "Science Fund." Preliminary techno-economic assessments necessary for scaling up the combined SC-CO_2 extraction process of GS and BC will also be carried out.
Names and Surnames of Research Group Members with Their Identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and Links to Corresponding Profiles	1. Ibraimov Zair Tairovich – H-index according to the Scopus database – 3, Scopus Author ID 57345388600, https://www.scopus.com/authid/detail.uri?authorId=57345388600. H-index according to the Web of Science – 2, Researcher ID LSK-8794-2024, ORCID ID 0000-0002-1476-3231 https://orcid.org/0000-0002-1476-3231 2. Tokpayev Rustam Rishatovich – H-index according to the Scopus database – 5, Scopus Author ID 56998810900, https://www.scopus.com/authid/detail.uri?authorId=56998810900. H-index according to the Web of Science – 2, Researcher ID D-3859-2015, ORCID ID 0000-0002-0117-4454 https://orcid.org/0000-0002-0117-4454
Publications list with links to them	K.K. Kishibayev, J.Serafin, R.R. Tokpayev, T.N. Khavaza , A.A. Atchabarova, D.A., Abduakhytova, Z.T. Ibraimov, J.Sreńscek-Nazzal. Physical and chemical properties of activated carbon synthesized from plant wastes and shungite for CO2 capture, Journal of Environmental Chemical Engineering, Volume 9, Issue 6, December 2021. https://doi.org/10.1016/j.jece.2021.106798 IF = 5.909, Q1, процентиль = 87. 2. J. Serafin, K. Kishibayev, R. Tokpayev, T. Khavaza, A. Atchabarova, Z. Ibraimov, M. Nauryzbayev, J. S. Nazzal, L. Giraldo and J. C. Moreno-Piraján. Functional Activated Biocarbons Based on Biomass Waste for CO2, Capture and Heavy Metal Sorption, ACS Omega. American Chemical Society, Volume 8, Issue 50, 2023. https://doi.org/10.1021/acsomega.3c07120, Q2, процентиль = 76. 3. R. Tokpayev, T. Khavaza, Z. Ibraimov, K. Kishibayev, A. Atchabarova, S. Abdimomyn, D. Abduakhytova, M. Nauryzbayev. Phosphogypsum conversion under conditions of SC-CO2, Journal of CO2 Utilization Volume 63, 2022. https://doi.org/10.1016/j.jcou.2022.102120 Q1, процентиль =

	90. 4. RR Tokpayev, ER Shreider, ZT Ibraimov, TM Shalakhmetova, MK Nauryzbayev. Decellularization of bone tissue in a supercritical carbon dioxide environment // International journal of biology and chemistry, 2023. Volume 16. P. 16-26 https://doi.org/10.26577/IJBCh2023v16i2a2
Patent information	-