

Brief information about the project

Name of the project	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	The high biological activity and nutrient content (saturated and unsaturated fatty acids, vitamins, and minerals) in grape seed oil (GSO) and black seed oil (BSO) attract the attention of many scientists. According to numerous studies, GSO has the potential for broad applications in the food industry as a preservative and as additives that improve the physicochemical properties of products. Additionally, BSO exhibits anti-inflammatory, antioxidant, antimicrobial, and anticancer properties, contributing to improved human health and recovery from various diseases. Globally, the total amount of waste generated by the wine industry reaches approximately 8-9 million tons, with phenolic compounds accounting for up to 70% of the total, making them a potential raw material for valuable products. However, despite existing studies, the impact of extraction methods on the oxidative stability and composition of GSO and BSO, as well as the potential synergistic effects observed when these oils are co-extracted, remain insufficiently explored. It is worth noting that combining GSO and BSO during the extraction process could balance their fatty acid composition, enrich them with valuable compounds, and enhance their oxidative stability. The supercritical CO₂ extraction (SC-CO₂) method is environmentally safe, cost-effective, and technologically efficient. Compared to traditional methods, SC-CO₂ extraction allows for favorable results in a shorter time, and SC-CO₂ as an extractant is readily available, inexpensive, non-toxic, and non-explosive. The aim of this project is to develop a zero-waste technology for producing functional oil (FO) based on GSO and BSO, as well as activated carbons (AC) from the pomace remaining, modified with urea and thiourea, after oil extraction. The project will investigate the synergistic effects observed during the co-extraction of GSO and BSO using SC-CO₂, as well as assess the oxidative stability and biological activity of the resulting oils. The project focuses on studying various extraction modes (static, dynamic, and combined), the ratio of grape seed to black seed, pressure, temperature, and their effects on FO yield, composition, and properties. The chemical composition of grape seeds (GS) and black seeds (BS), antioxidant activity, oxidative stability, FO toxicity, pomace carbonization, the physicochemical properties of AC, and modification methods will also be examined. It is expected that joint SC-CO₂ extraction will enhance oxidative stability and balance the fatty acid

	composition of the FO. The resulting FO may find widespread use in the food, pharmaceutical, and cosmetic industries.
Purpose	The project goal is to develop a technology for joint supercritical CO ₂ extraction of grape seed oil and black cumin oil to produce functional oil with high oxidative stability and a balanced fatty acid composition, as well as high-performance activated carbons from grape seed and black cumin oil meal.
Objectives	1. study of the qualitative and quantitative composition of grape seed and black cumin seeds; 2. study of the effect of the mode of joint SC-CO₂ extraction (static, dynamic and combined) on the qualitative and quantitative composition of GSO and BSO; 3. study of the effect of pressure, temperature in the extractor and separator on the qualitative and quantitative composition of GSO and BSO; 4. study of the oxidative stability, fatty acid composition, nutritional properties of the obtained FO; 5. Toxicological assessment of the obtained FO; 6. Study of the properties of the activated carbon (sorption capacity for methylene blue, copper, and lead, pore size) obtained after the removal of vegetable oils; 7. Development of a waste-free technological scheme for the production of FO and activated carbon.
Expected and achieved results	The results of this project will be reflected in the form of scientific publications, namely, at least 2 (two) articles in journals from the first three quartiles by impact factor in the Web of Science database or having a percentile by CiteScore in the Scopus database of at least 50. The results are expected to be published in the following journals (Food chemistry, percentile 97%, Q1, Chemical Engineering and Processing ghjwtynbkm 83%, Q2 or others). Also, based on the results obtained, 1 PhD doctoral thesis will be written and defended. A utility model patent will be obtained from the Kazakhstan Patent Bureau. Functional oil with increased oxidative stability, balanced fatty acid composition and high antioxidant activity will be obtained due to the manifestation of the synergism effect observed during the joint SC-CO₂ extraction; activated carbon based on grape seed and black cumin with high sorption activities, modified with urea and thiourea. The obtained FO will be toxicologically evaluated according to the following indicators: the content of benz(a)pyrene, erucic acid and the residual amount of pesticides. The final result is a waste-free technology for obtaining FO by the method of joint SC-CO₂ extraction from GS and BS and modified AC. The resulting FO can be widely used in the food (for frying, salad dressings, and natural preservatives), cosmetic (creams and cosmetic oils), and pharmaceutical (capsules with functional oils and ointments) industries as

	a product with a high content of antioxidants, vitamins, a balanced fatty acid composition, and a longer shelf life. The AC will be obtained from GS and BS meal, modified with urea and thiourea. The resulting sorbents will allow the extraction of heavy metals such as copper and lead from wastewater. After the project is successfully completed, an application will be submitted to participate in the GF Young Scientists Competition, with the possible further commercialization of the project through the Science Foundation JSC. Preliminary technical and economic calculations will be conducted to scale up the process of joint SC-CO₂ extraction of GSO and BSO. The following results have been achieved: the necessary materials and equipment have been purchased, and the parameters of the SC-CO₂ extraction processes of GSO, BSO, and FO have been optimized. The oxidative stability has been evaluated.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	Ibraimov Zair Tairovich, PhD candidate, lecturer. H-index– 2, Author ID Scopus – 57345388600, ORCID ID 0000-0002-1476-3231 Tokpayev Rustam Rishatovich, PhD, H-index– 4 Author ID Scopus – 56998810900 Researcher ID Web of Science D-3859-2015, ORCID ID 0000-0002-0117-4454, Researcher ID in Publons D-3859-2015
Usage	Food, chemical and pharmaceutical industries
Priority compared to real-world alternatives	In comparison with existing analogues FO has high oxidative stability, balanced fatty acid composition and bioactive properties. Modified AC will have increased selectivity.
List of publications with links to them	-
Patents	No