Brief information about the project

Title	AP22685606 «Development of highly sensitive "green" methods for the analysis of residual amounts of pesticides in grapes».
Relevance	Grapes are one of the most widely cultivated fruit crops in the world. They are consumed both fresh and in processed forms such as wine, juice, and raisins. Due to their high carbohydrate content, grapes are highly susceptible to fungal diseases and insect infestations. To combat these issues, pesticides are commonly used in viticulture. However, the use of pesticides can lead to the accumulation of their residues in grape products, posing a potential threat to consumer health and affecting the international competitiveness of the produce. Pesticide residues may also harm the environment, reduce the quality of grape products, and have adverse effects on human health. Current methods for analyzing pesticide residues in grapes are costly (due to the high prices of materials and reagents), involve multiple steps in sample preparation, are time-consuming, and have limited capabilities for simultaneously detecting more than 20 pesticides at low concentrations. These methods also tend to have low sensitivity and do not meet the modern standards of green chemistry. Therefore, the development of affordable, sensitive, accurate, and environmentally friendly analytical techniques for determining pesticide residues in grapes is a highly relevant and important task.
Goal	Development of two accurate and environmentally friendly methods for the determination of pesticide residues based on vacuum and miniaturized solid-phase microextraction combined with chromatographic–mass spectrometric detection.
Tasks	**№1.** Development of a quantitative method for the determination of pesticide residues in grapes using vacuum solid-phase microextraction (vacuum-SPME) combined with gas chromatography–mass spectrometry (GC-MS). **№2.** Development of a quantitative method for the determination of pesticide residues in grapes using miniaturized solid-phase microextraction (mini-SPME) combined with gas chromatography–mass spectrometry (GC-MS). **№3.** Evaluation of the environmental sustainability of the methods based on vacuum-SPME and mini-SPME using modern tools such as GAPI (Green Analytical Procedure Index) and AGREEprep (Analytical Greenness Metric Approach). **№4.** Testing of the developed methods on various grape varieties sampled from local vineyards and retail markets in Kazakhstan.
Expected and Achieved Results	**Expected Results for Task №1:** - The key parameters affecting solid-phase microextraction of pesticides from grape matrix will be studied, including extraction time and temperature, optimal extraction coating, sample volume and pre-incubation time, vessel pressure and its effect on extraction intensity and reproducibility, as well as the matrix effect on the accuracy and reliability of results. - A quantitative determination range for semi-volatile

	pesticides such as propiconazole, atrazine, metribuzin, oxyfluorfen, fluroxypyr-methyl, epoxiconazole, tebuconazole, quizalofop-P-methyl, boscalid, chlorpyrifos, and others will be established using vacuum-SPME. - Limits of qualitative and quantitative detection of pesticides in grapes will be determined, supported by an evaluation of response linearity and reproducibility, confirmed by testing in two chromatographic laboratories. **Expected Results for Task №2:** - Key parameters for miniaturized solid-phase microextraction (mini-SPME) will be identified, including extraction temperature and time, pre-incubation time, and optimal sample volume, to ensure effective extraction of target pesticides from the grape matrix. - Quantitative determination ranges for pesticides such as propiconazole, atrazine, metribuzin, oxyfluorfen, fluroxypyr-methyl, epoxiconazole, tebuconazole, quizalofop-P-methyl, boscalid, and chlorpyrifos will be established using mini-SPME. - Limits of qualitative and quantitative detection will be determined, with verification of the reliability of linear characteristics and reproducibility based on testing in two analytical laboratories. **Expected Results for Task №3:** - An environmental assessment of the developed pesticide analysis methods in grapes using vacuum-SPME and mini-SPME will be conducted, employing modern tools such as GAPI (Green Analytical Procedure Index) and AGREEprep (Analytical Greenness Metric Approach). - The assessment will be carried out using open-source software that generates a visual color-coded pictogram, clearly presenting the overall "greenness" of the analytical procedure. **Expected Results for Task №4:** - The developed quantitative methods for pesticide determination will be tested on various grape varieties collected from the southeastern regions of Kazakhstan. - The new "green" analytical methods will be implemented in food quality control laboratories. - Dissemination and promotion of the developed methods will be carried out both locally and internationally.
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Publications list with links to them	1) **Y. Syrgabek, M. Alimzhanova, S. Yegemova, S. Batyrbekova.** *Vacuum-assisted headspace-solid phase microextraction of pesticides in grape samples*, *Advances in Sample Preparation*. 11 (2024) 1–15. https://doi.org/10.1016/j.sampre.2024.100123 (Q1, Impact Factor: 5.2, Percentile: 84.4%) 2) **Y. Syrgabek, M. Alimzhanova.** *Eco-friendly miniaturized solid phase microextraction for pesticide analysis in grapes*, *Journal of Separation Science, https://doi.org/10.1002/jssc.70204* (Q2, Impact Factor: 2.8, Percentile: 59.9%)
Patent information	Not available