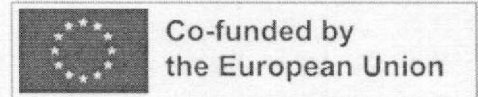
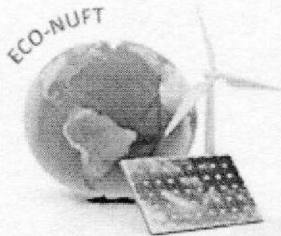
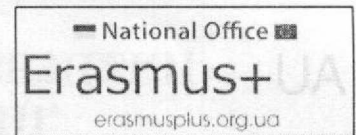


MINISTRY OF EDUCATION
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SYSTEMS FOR AUTHENTICATING BEEKEEPING PRODUCTS AS AN ELEMENT OF SUSTAINABLE DEVELOPMENT AND DIGITAL TRACEABILITY

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The contemporary development of the beekeeping products market is accompanied by growing demands for quality, safety, and confirmation of authenticity of origin. This is particularly relevant in the context of trade globalization, expanding exports, and the tightening of traceability standards in accordance with international sustainable development requirements. The authenticity of beekeeping products – honey, propolis, royal jelly, pollen, beeswax, and others – is a critical factor in ensuring consumer trust, product competitiveness on global markets, and the formation of transparent supply chains. Among the most promising methods for assessing the quality and authenticity of honey are the following (Jacque et al., 2023): sensory analysis; analysis of physicochemical parameters; analysis of the antioxidant activity of honey and analysis of the presence of flavonoids; nuclear magnetic resonance spectroscopic analysis; analysis of the isotopic composition of honey using $^{13}\text{C}/^{12}\text{C}$ isotope-ratio mass spectrometry measurement; infrared spectroscopic analysis; analysis of the microbiological purity of honey; and chromatographic analysis of honey composition, among others. In this context, the introduction of modern analytical and digital quality control technologies acquires particular significance.

The integration of artificial intelligence enables the automation of identification processes for beekeeping products and enhances the accuracy of expert quality assessment. The implementation of digital traceability technologies (Ornelas et al., 2025) – in particular, blockchain-simplifies transaction monitoring. It also facilitates data verification during processing and transmission. Furthermore, customers can access detailed product information, for example via QR codes. This aligns with the current requirements of international trade and export certification. The adoption of the advanced authentication technologies for beekeeping products discussed above directly contributes to the achievement of key Sustainable Development Goals, namely: goal 2 «Zero Hunger» by ensuring access to safe and high-quality food products; goal 3 «Good Health and Well-being» by reducing the risks associated with the consumption of adulterated products; goal 9 «Industry, Innovation and Infrastructure» by introducing digital and spectroscopic quality control technologies; and goal 12 «Responsible Consumption and Production» by establishing modern, transparent product traceability systems.

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