

MONIKA KRZYŻOSTAN

Development of a new line of environmentally and skin-friendly, natural and biodegradable dermocosmetic products compliant with the principles of sustainable development and Ecocert/COSMOS requirements

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The Green Deal policies proposed by the European Commission, such as the circular economy and zero emissions, have led to an increase in demand for the creation of sustainable cosmetic products with a significantly reduced impact on the environment. The assumptions of the Green Deal are met by the COSMOS standards for natural and organic cosmetics, providing a holistic and comprehensive view of the cosmetic manufacturing process. Simultaneously, on the market lacks specialist dermocosmetics intended for the care of atopic skin, containing active ingredients of natural origin with effects confirmed by scientific research and created in the spirit of sustainability. Due to the multidirectional mechanism of action of triterpene saponins from *Centella asiatica* L., described in the literature, this plant can demonstrate a great potential in inhibiting inflammatory processes that occur on the skin of people with atopic dermatitis (AD), as it has been confirmed in in vivo studies on mouse models. In addition, the plant fermentation process allows the production of a raw material with a postbiotic effect supporting the restoration of the balance of the atopic skin microbiome.

The main objective of the research was to develop an optimized technology for the production of three natural dermocosmetic products compliant with the COSMOS standards, based on the emollients and an extract and bioferment obtained from the leaves of *Centella asiatica* L., intended for the care of atopic skin, as well as to confirm the effectiveness of their action by in vivo tests. Three of the five developed products were the subject of the submitted dissertation.

The doctoral dissertation was prepared in the form of a coherent series of articles published in scientific journals from the list of the Ministry of Science and Higher Education. The review article D1 describes the assumptions of the Green Deal and the methods of its implementation in the cosmetics industry. In reference to the circular economy, the upcycling of waste from the food industry was presented, as well as extraction and biofermentation methods for their processing into sustainable cosmetic raw materials. The review article D2 shows the properties, application, and structure of triterpene saponins isolated from the leaves of *Centella asiatica* L., such as madecassoside, asiaticoside, madecassic acid, and asiatic acid. The experimental publication D3 presents an environmental assessment of raw materials and an optimized, low-energy process for the production of various cosmetic supports, namely: w/o, o/w emulsions and gel. The stability studies of the obtained supports are described, and the release profiles of madecassoside and asiaticoside are discussed in detail with a reference to their concentration, type of the cosmetic support, and pH of the acceptor fluid. The release

mechanisms were analyzed based on four kinetic models. In the experimental publications D4 and D5, the results of in vivo studies on the effectiveness of dermocosmetic products in atopic skin, the formulations of which were developed based on previously obtained cosmetic supports, are described.

During the studies, the technological process of obtaining w/o, o/w emulsions and gel was optimized, aiming at reducing the carbon footprint in the environment. Physicochemical parameters were examined and the stability of formulations was confirmed using laser diffraction (LD), electrophoretic light scattering (ELS), and static multiple light scattering (SMLS) techniques. The stability of madecassoside and asiaticoside in cosmetic supports was confirmed by HPLC. Based on the release profile of madecassoside and asiaticoside, the most optimal carriers matched to the needs of atopic skin were selected and formulations of body lotion, hand cream, and face cream were developed. Their effectiveness on the skin was confirmed in randomized, single-blind and placebo-controlled in vivo studies with the participation of volunteers with AD.