Nanostructured lipid systems with *Cannabis sativa* L. extracts in the regulation of skin aging processes and microbiome balance based on the concept of multifunctionality

Why do we age – and can nature help slow it down? Our skin is the body's largest organ and one of the first to show signs of aging. Daily exposure to sunlight, pollution, and stress weakens the skin's protective barrier, accelerates aging, and disrupts the delicate balance of skin microbiota – the community of microorganisms essential for healthy skin. Scientists are now exploring new ways to delay these processes using safe, plant-based ingredients.

This project aims to develop advanced, multifunctional skincare formulations using natural extracts from ***Cannabis sativa L.*** (hemp), which are rich in biologically active compounds like cannabidiol (CBD). These extracts come from **patented Polish cannabis strains** developed at the Institute of Natural Fibres and Medicinal Plants (IWNIRZ) – National Research Institute.

CBD will be enclosed in proven efficient nanocarriers (Solid Lipid Nanoparticles, SLN) and incorporated into biodegradable nanofiber films using electrospinning technology to increase their effectiveness and stability. This combination is designed to deliver active compounds directly to the skin, improving their penetration and durability.

The research will involve a wide range of biological models – from human skin cells, through **skin-on-a-chip systems**, to model organisms such as **zebrafish** and ***C. elegans*** – to thoroughly test the anti-aging, antioxidant, anti-inflammatory, and microbiome-balancing properties of the developed formulations.

The expected outcome? A scientifically validated prototype of a modern formula designed for topical skin application that is natural, effective, and microbiome-friendly. The project will not only support innovation in skincare but also provide valuable knowledge on how cannabinoids affect skin health and aging. The obtained results may contribute to the development of advanced skincare products and medical applications that are safe, effective, and better tailored to users' needs (FIGURE 1).

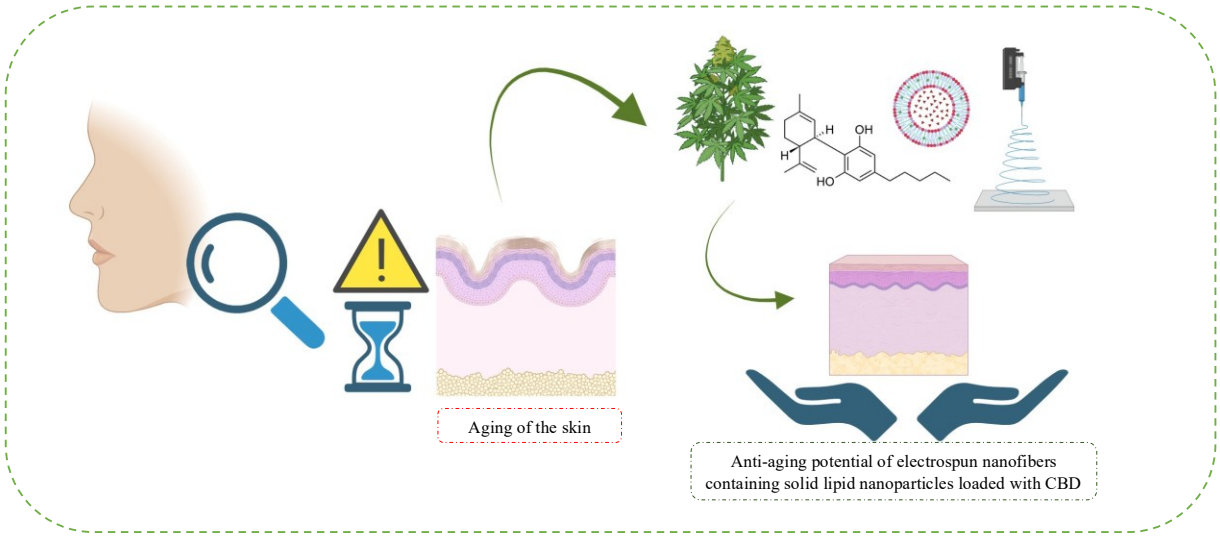

FIGURE 1. Schematic representation of the project concept. The graphic illustrates the research approach based on the use of *Cannabis sativa* L. extracts in nanostructured lipid systems, aimed at delaying skin aging processes and regulating the skin microbiome, grounded in the idea of multifunctionality.