

Colorectal cancer is the third most common malignancy worldwide. It is estimated that by 2040, the number of patients with colorectal cancer will reach 2.4 million, resulting in 1.3 million deaths worldwide. A factor contributing to the low survival rate of people with colorectal cancer is the hidden early onset of symptoms. Therefore, prevention plays a crucial role, particularly for individuals belonging to high-risk groups. In this context, it is known that polyphenolic compounds obtained from plant matrix, administered as part of the diet, can be a promising tool in cancer prevention. Therefore, the search for new sources of plant extracts high in polyphenolic compounds with defined therapeutic potential remains important and relevant for modern phytochemistry. This group of plants includes berries, whose seeds are extremely attractive from a health-promoting and industrial perspective. Seeds are byproducts with largely unexplored health-promoting potential, which inspires the need for broader phytochemical analyses and evaluation of mechanisms of activity for their effective use. However, polyphenolic compounds are among the components with low bioavailability and limited tissue distribution, thus losing their properties. One method of protecting them could be nanoencapsulation using mesoporous silica materials. Besides stabilizing polyphenolic compounds through the formation of nanoparticles, it is also necessary to ensure their delivery to the target site, i.e., the colon, which may be achieved by encapsulating them in colon-specific microcapsules. However, there are still a limited number of reports on the development of such oral formulations.

Therefore, the main goal of the project is to utilize the cytotoxic properties of polyphenolic compounds from waste products, such as berry seeds, to design multifunctional nanoparticles suspended in microcapsules that target colon cancer cells.

The research will focus on assessing the *in vitro* cytotoxic properties of berry seed extracts against colon cancer cells, identifying the polyphenolic fractions responsible for these effects and developing an efficient technology for their isolation. Another crucial aspect will be loading selected fractions with nanoparticles and then obtaining bilayer microcapsules using ionotropic gelation, targeting the delivery of the nanoparticles to the colon. The research panel, covering both active polyphenolic compounds and nanoparticles and microcapsules, will include a comprehensive analysis of cytotoxicity against colon cancer cells, identifying the mechanisms of activity, as well as an analysis of stability and bioavailability during simulated *in vitro* digestion, physicochemical analysis, and a safety assessment.

The results of the research will enable the determination of a comprehensive polyphenolic profile of seeds from a broad group of berries and will indicate the most appropriate methods for their stabilization through nano- and microencapsulation to target their activity against colon cancer cells. The results obtained in the future, after conducting *in vivo* and clinical studies, may constitute an essential starting point for the use of the developed microcapsules in the design of nutraceuticals and/or functional products dedicated to people with an increased risk of developing colorectal cancer, and may also contribute to the development of oral cancer prevention systems based on natural compounds.