Preparation and properties of starch interaction products with ferulic acid

Kamil Dędek, M. Sc. Eng.

Supervisor: Associate Professor, Justyna Rosicka-Kaczmarek, Ph.D., D.Sc.

Auxiliary supervisor: Karolina Miśkiewicz, D.Sc.

Abstract

Starch is the main representative of polysaccharides of the plant world and at the same time the most important carbohydrate in the human diet. Next to synthetic polymers, it is nowadays an increasingly used natural, renewable and sustainable source for the preparation of micro-scale materials. Bioactive components including ferulic acid (FA) are characterized by thermolability and high susceptibility to oxidation, which may limit the full utilization of their health-promoting potential. As reported in the scientific literature, one effective solution to protect and preserve the health-promoting potential of bioactive components may be the use of a polysaccharide microencapsulation process. This process uses the technique of encapsulating the accepted ligand inside the polysaccharide envelope, thus reducing the exposure of bioactive substances to undesirable factors such as low pH, access to light and oxygen and oxygen, high temperature or relative humidity.

Ferulic acid (FA) is an organic chemical compound belonging to the group of phenolacids with the overall formula $C_{10}H_{10}O_4$. According to research, FA exhibits strong antioxidant, anti-inflammatory and antibacterial properties and bactericidal properties. Basically, it prevents the formation of blood clots and heart attack. Significantly lowers the level of unfavorable fraction of cholesterol (LDL) and blood glucose levels. Protects the liver from the effects of xenobiotics. In addition, it stops harmful UV radiation, supports the treatment of rosacea and dermatitis.

Based on the reports in the scientific literature on the important health-promoting aspects of FA in the field of medicine and cosmetology and the possibility of using the polysaccharide microencapsulation technique to protect bioactive components, the aim of this study was to obtain stable interaction products of wheat and potato starches and potato starch with FA using spray drying and sublimation methods. The effectiveness of the interaction was evaluated taking into account the physicochemical (e.g. water and fat binding capacity, water solubility, amount of dietary fibre - resistant starch, RS) and biological (e.g. antioxidant potential, anti-inflammatory and prebiotic properties) properties exhibited by the obtained formulations. Finally, an attempt was made to design a food application, i.e. gluten-free breads, obtained with starch ferulates in the formulation.

The conducted studies have shown that as a result of the application of an appropriate sequence of processes and appropriately selected parameters and reactants, it is possible to obtain stable products of interaction of natural wheat and potato starch ferulic acid, obtained using an innovative "*green methods*", i.e. a concept based on designing and carrying out chemical processes in such a way as to reduce the use and generation of harmful substances, which, according to the scientific literature, was not achievable with natural starch. The obtained starch ferulates had on average 20 times higher stability under simulated intestinal digestion conditions, compared to natural ferulic acid. Furthermore, the polysaccharide microencapsulation process was shown to improve the bioavailability of ferulic acid after gastrointestinal digestion by an average of 10-fold,

compared to its natural form. It was also shown that the resulting starch ferulates, due to their increased dietary fiber content (RS starch), exhibited proadhesive properties to model biotic surfaces (collagen and mucus) and provided a readily available carbon source for lactic acid bacteria (LAB) and *Bifidobacteria*. In addition, it was investigated that the starch ferulates could provide a novel raw material used by the gut microbiota for the production of metabolites with significant health-promoting potential, i.e., short-chain fatty acids (SCFAs), including propionic acid, butyric acid, and acetic acid. Moreover, it was shown that the obtained starch ferulates exhibit significant anti-inflammatory potential and have statistically significant ($p \leq 0.05$) effect on reducing intracellular levels of reactive oxygen species (ROS), which proves their protective properties towards cells, thus protecting them against oxidation of proteins, lipids and DNA.

An attempt to develop a recipe and a method of obtaining gluten-free breads with the participation of starch ferulates, confirmed one of the possible directions of their application. Breads obtained were characterized by increased antioxidant potential in comparison with the control sample, i.e. gluten-free bread without starch ferulate. Moreover, according to respondents taking part in the sensory panel, evaluated products with 5% addition of starch ferulates did not differ significantly in their parameters from the control sample.

Taking into account the results obtained, it can be concluded that the obtained starch ferulates can be a new, innovative component of food products, with potential health-promoting properties, including, which should be emphasized, with significantly increased stability and bioavailability of ferulic acid and a significant antioxidant potential, compared with natural starch. Also noteworthy is the method used to obtain the starch ferulates, which is in accordance with the requirements of the principles of so-called "*green chemistry*", which does not generate environmental pollutants.