1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: A new generation of regenerative tonics based on mineral waters from Ciechocinek with the addition of biologically active ingredients: from the laboratory to the technological scale

1.1. Project goals

The aim of the doctoral project is to develop and produce prototype recipes of new nutritious drinks based on mineral water from the area of the Kuyavian-Pomeranian region enriched with natural products and plant extracts of pro-health character. The selected natural products include honey from regional apiaries, fresh fruit juices, fruit pulps and herbs. Due to their unique composition, they are a source of valuable compounds with nutritional and health-promoting properties. Moreover, the present microflora will enrich the organoleptic properties of the product and the addition of phenolic compounds with antioxidant properties and polyunsaturated fatty acids with anti-atherosclerotic effect will have a direct impact on its health-promoting and sensory properties and will translate into an extended shelf life. Within the scope of the PhD project, waters of our region will be characterized in terms of both microbiological and qualitative aspects, the procedure for extraction of phenolic compounds and unsaturated fatty acids will be developed, which will form the basis for the characterization of the cocktail prototype. Finally, a recipe will be developed for the preparation of regenerative tonics based on nutritious drinks from mineral water, aimed at a wide range of consumers who care about their health.

1.2. Outline

Mineral waters from the area of the Kujawsko-Pomorskie Voivodeship, and in particular from Ciechocinek, are the most popular spa product and one of the mineral waters which have been present on the market for the longest time. Mineral water from Ciechocinek is highly mineralized with a slightly salty taste. During the technological process it is filtered with iron removers. Its unique composition is characterised by high content of chlorine and sodium ions, thanks to which it is perfect for replenishing mineral salts excreted from the body. In addition, it contains significant amounts of magnesium, which is one of the most important bio-elements

necessary for the proper functioning of the body, and calcium - the building block of the human skeleton. Moreover, it is a source of valuable micro- and macroelements such as bromine, iodine, nickel, selenium, lithium. The values of ratios of chlorine and bromine ions (Cl-/Br-) and bromine and iodine ions (Br-/J-) indicate the predominance of salinity originating from salt dissolution. Water samples collected from some of the wells have been shown to have a stable chemical composition. The sum of solids in this water is 3416.58 mg/l [1]. The high content of solids in mineral water has caused limitations in its preservation, storage and use, especially by people with health problems (e.g. diabetes, hypertension or gout). Therefore, the use of ultrafiltration techniques to normalize mineral levels with the addition of bioactive compounds such as plant extracts and natural compounds or fruit pulps is highly desirable [2].

Therefore, one of the most important parts of this work will be selection of regional natural products from Kujawsko-Pomorskie province. These natural products will be e.g. honeys from regional apiaries, fresh fruit juices and herbs and development of a method for the analysis of their extracts containing compounds such as: cyclitols, polyphenols and other biologically active compounds. The extracts containing the mentioned compounds were characterized and quantified using different techniques such as ICP-MS, GC/MS, LC-MS/MS, GPC, FT-IR, capillary zone electrophoresis, ion exchange chromatography, spectrophotometry and other analytical techniques. Choosing the most appropriate method for separation and quantification of bioactive compounds from plants and natural products is an important part of the analytical procedure. Due to the bioactive properties of compounds, such as antioxidant, antimicrobial, and anti-inflammatory activities, natural substances found in different parts of plants are of interest. These properties are also extremely important when considering the target audience of these substances. These groups include primarily athletes (amateurs, hobbyists and professionals), chronically ill people (diabetics, cancer patients, hemangiomas), the elderly, and especially the elderly with comorbidities. Preparation of mixtures with different proportions of substances is able to help the mentioned target groups by, among others: improving the efficiency of the body, stimulating the nervous and muscular systems, reducing muscle acidification, regulating mineral metabolism, reducing the content of toxins, improving kidney function or increasing appetite due to taste qualities.

1.3. **Work plan**

1. Physicochemical and microbiological characterization of mineral waters and whey using chromatographic, electrophoretic, spectroscopic and spectrometric techniques

2. Development of membrane techniques for the acquisition and concentration of lithium content in water

3. Development of a pressure- and temperature-assisted extraction (ASE) and supercritical fluid (SFE) extraction method for selected plants and natural products (e.g. honey), lactic acid bacteria (LAB) isolation

4. Development of a desalination membrane and desalination by precipitation. Studies of dispersion stability, a system of colloidal proteins, fats and milk, sugar, filtrates / precipitates

5. Formulation of the beverage prototype based on whey, microbiological isolates and plant extracts and natural products for pre- and fermented systems

6. Proposing a project of a potential technological line allowing the production of a nutritional drink based on prepared recipes

1.4. Literature

[1] Krawiec A., Nowe wyniki badań izotopowych i chemicznych wód leczniczych Ciechocinka, Przegląd Geologiczny, Vol 47, No 3 (1999)
[2] Jovanović S., et al. Whey proteins-Properties and Possibility of Application. Mljekarstvo 55 (2005) 215-233
[3] Królczyk J.B., et al. Use of Whey and Whey Preparations in the Food Industry – a Review. Pol. J. Food Nutr. Sci. 66 (2016) 157–165.
[4] Lee Y.H. Food-processing approaches to altering allergenic potential of milk-based formula. J. Pediatr. 121 (1992):S47-50.
[5] Fernández-Gutiérrez D., et al. Biovalorization of saccharides derived from industrial wastes such as whey: a review. Rev. Env. Sci. Biotech. 16 (2017), 147-174.
[6] Youssef M.K. and Barbut, S. Effects of two types of soy protein isolates, native and preheated whey protein isolates on emulsified meat batters prepared at different protein levels. Meat Sci. 87 (2011) 54–60.

1.3. Required initial knowledge and skills of the PhD candidate

PhD for the implementation of the project candidate should be skilful and familiar with the extraction techniques: maceration, ASE, SFE and separation techniques: ultrafiltration, LC-MS and GC-MS. Candidate should have also experience of work with isolation, culturing and identification of microorganisms as well as preparation of different culture media. Knowledge in the field of

food chemistry will be highly honoured. Knowledge of work in programs used for identification of mass profiles of microorganisms like LC/GC ChemStation (Agilent) will be favoured.

1.6. Expected development of the PhD candidate's knowledge and skills

PhD candidate will gain knowledge and skills in the field of analytical chemistry, sample preparation and microbiology. Candidate will get specialized knowledge in separation science, microbial identification, and extraction approaches.

Moreover, the interpretation of analytical and statistical data will be developed during PhD study. During the study student will be able to present obtained data in form of high-impact factor publication and posters and oral presentations at domestic and international conferences.