Is metabolic effect of copper nanoparticles reliant on dietary fibre with different physiological function?

Research hypothesis: Dietary copper (Cu) is required for normal functioning of numerous basic biochemical and physiological processes in the organism. Recently, nanoparticles have emerged as important players in modern science, including nutritional status of the host in health and disease. A nanometer (nm) is one thousand millionth of a meter. A single human hair is about 80,000 nm wide, a red blood cell is approximately 7,000 nm wide, a DNA molecule (it is a nucleic acid that contains the genetic instructions for the development and function of living things) 2 to 2.5 nm, and a water molecule almost 0.3 nm. Food and nutrition products containing nano-scale additives are already commercially available. In the series of the own experiments, we have shown the pros and cons of dietary copper nanoparticles (Cu-NP) on the intestinal, circulatory system, internal organs and brain functioning. For instance, we have shown that in comparison to commonly used dietary CuCO3, Cu nanoparticles (at recommended Cu dietary level) to a greater extent were absorbed from the intestine, accumulated in brain tissue, exerted antimicrobial effect in the caecum, enhanced lipid oxidation processes and caused morphological damages in the liver and lungs of rats. On the other hand, replacing CuCO3 with copper nanoparticles advantageously protects proteins and DNA against oxidation processes in laboratory rats. Due to wide physiological effect of the Cu-NP in the whole organism it might be important to regulate its area of reactivity. There is no doubt that the start of the story is in the intestine where the absorption processes would decide what amount of nutrients and non-nutrients enter the body systems. Moreover, the intestinal environments themselves, both as the upper and lower gut, modulate metabolic body response through e.g. activation of intestinal immunological cells and stimulation or thwarting of the “forgotten organ” – large intestinal microbiota. One of the paramount dietary components is fibre, and its type would play a crucial role in the assimilation and then physiological activity of Cu-NP. Therefore the main aim of this project is to verify the statement that the physical, chemical and biological properties of dietary fibre largely affect the intestinal and other internal organs activity of Cu-NP, thus modulate the health status of the body. We hypothesized that a dietary combination of copper nanoparticles with either a control inert (cellulose; almost no effect on digestion processes and intestinal microbiota activity) or a prebiotic (inulin; it stimulates the growth of beneficial bacteria and depressed the growth of bad microbial species) or a viscous (high viscosity pectin; in the intestine it makes viscous digesta and delays the absorption of nutrients and non-nutrients in the small intestine) or a bulking (psyllium; it prevents constipation by increase of digesta passage through the gut) fibre would affect physiological responses in the gastrointestinal tract and thus regulate effect of this form of dietary Cu in the organism.

The laboratory rat will be used as a research model, i.e. an established host model for nutritional and physiological studies, including the gastrointestinal and metabolic responses to nutritional interventions. To our best knowledge, and after searching for the literature on replacement possibilities for our animal model, up to date there are no alternatives appropriate for achievement of our objectives. The complexity of biological processes in the small and large gut and in the body in relation to dietary inclusion of test components cannot be recapitulated in vitro, therefore the whole living organism is required.

The main intention of the project’s authors is to bring as much as possible new insight with regard to the question which properties of dietary fibre would support the “good face” and alleviate the “bad face” of ingested copper nanoparticles in the intestine and other internal organs, thus affecting the whole body functioning.