SUMMARY

The development of nanotechnology and nanoscience has led to groundbreaking advances across multiple fields. The ability to manipulate matter at the atomic and molecular level has enabled the creation of materials with unique properties that are not present on a macroscale. Nanoparticles and nanomaterials have found applications in medicine and pharmaceuticals, electronics, energy, the production of specialized materials, food production and preservation, environmental monitoring, as well as water and air purification. This progress opens new possibilities across various industries but also presents challenges in terms of safety and ethics, especially regarding the impact of nanoparticles on human health and the environment.

Although nanoparticles hold remarkable potential across diverse fields, their small size and unique chemical properties can lead to unpredictable interactions with living organisms and ecosystems. Therefore, the uncontrolled release of nanoparticles into the environment raises justified concerns. Knowledge on their bioaccumulation and biomagnification, impact on soil, water, and air quality, as well as their toxicity to organisms, including human health, remains fragmented and insufficient. For these reasons, research assessing the impact of nanoparticles on biological functions is one of the key challenges in nanoscience.

This doctoral dissertation focuses on assessing the impact of graphene oxide nanoparticles (GO), silver nanoparticles (AgNPs), and a composite made from GO and AgNPs on the digestive functions of the model organism *Acheta domesticus*. The study involved measuring selected parameters of the digestive budget and enzymatic activity, under the assumption that any xenobiotic disrupts the organism's functions and necessitates energy allocation for neutralizing its effects. The primary aim was to determine the relationship between exposure to the aforementioned nanoparticles and food consumption/assimilation, digestive enzyme activity, and intestinal cell health in *Acheta domesticus*. In addition to nanoparticle type, exposure concentration and duration were also considered parameters.

In the first part of the study (manuscript 1), food consumption and digestive enzyme activity were analyzed in insects exposed to GO, AgNPs, and the composite, administered in individual concentrations of 20 µg/g (GO), 400 µg/g (AgNPs), and 20/400 µg/g (GO/AgNPs). An early effect was a reduction in energy assimilation, followed by compensatory increases in consumption. These changes were accompanied by an initial increase in the activity of certain digestive enzymes in the first days of exposure. However, this effect diminished after several days, resembling a typical stress response with an initial alarm phase followed by resistance. The results were discussed in the context of hormesis theory, due to the observed stimulation 6

of some parameters. Furthermore, it was suggested that hormetic effects may be more noticeable in younger individuals, who have lower cumulative xenobiotic exposure and shorter exposure periods.

In the second part (manuscript 2), the effects of GO and AgNPs on the feeding functions of *A. domesticus* were analyzed over a wider range of concentrations and at different life stages of this species. The study showed stronger effects from AgNPs compared to GO, including increased activity of α-amylase, α-glucosidase, and lipase, accompanied by protease inhibition. Moreover, prolonged exposure to higher concentrations of AgNPs in adult crickets significantly reduced food consumption and altered assimilation compared to the control group. Notably, weight gain in *A. domesticus* was observed only in the group exposed to the lowest AgNPs concentration, suggesting that these nanoparticles may not follow a simple dose-response rule, with underlying interactions between

nanoparticles (agglomeration) and food substrates that may mitigate toxic effects at higher concentrations.

The third experiment (manuscript 3) focused on the effects of the GO/AgNPs composite, at various concentrations and exposure durations, on *A. domesticus* digestive functions. Histological changes in intestinal cells were also assessed. Results indicated that both composite concentration and exposure time significantly influenced the evaluated parameters. In general, the composite reduced food intake and assimilation, while reactive oxygen species (ROS) levels in intestinal cells increased in groups exposed to higher composite concentrations. Additionally, the highest composite concentration inhibited protease activity. Histological analysis revealed structural damage to the intestinal epithelium and signs of autophagy or necrosis at higher composite concentrations.

The findings of this study indicate that GO, AgNPs, and their composite can destabilize the digestive functions of organisms and therefore should not be considered fully safe for the environment, especially when used in high concentrations or during prolonged exposure.