MODULATION OF EFFICIENCY OF NANOSTRUCTURED NISIN

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Nisin is a widely known lantibiotic often used in food processing as a natural preservative. Nisin exhibits a wide spectrum of antimicrobial activity against Gram-positive bacteria, however, many Gram-negative bacteria are nisin-resistant, so cell wall-permeabilization is required [1,2]. Nisin is sensitive to proteolytic degradation; it is known, that nano-encapsulation of bacteriocins protects them from degradation and can also increase their stability [3]. In this study, we used nisin-loaded pectin nanoparticles (NPs) in combination with nanosecond and microsecond pulsed electric fields (PEFs) to inhibit the growth of two strains of Gram-negative bacteria (*Eschericia coli*, *Salmonella enterica*) and one strain of Gram-positive bacteria (*Listeria innocua*). Also, we investigated the activity of magnetic nisin-loaded iron oxide NPs capped with citric, ascorbic and gallic acid, which were activated by high pulsed electric and electromagnetic fields against Gram-positive *Bacillus subtilis* and Gram-negative *E. coli*.

First of all, the minimum inhibitory concentration of nisin-loaded pectin NPs and free nisin samples was estimated. The encapsulated form of nisin has a better antimicrobial effect against both, Gram-positive and Gram-negative bacteria strains, in comparison to free nisin sample.

Secondly, we have applied a combination of NPs and 10-30 kV cm^{-1} electric field with different electric pulse duration (500 ns-100 μs) for inactivation of *E. coli*. It was determined that the 20-30 kV cm^{-1} electric field with pulses from 500 to 900 ns is efficient for permeabilization of *E. coli* and triggers synergistic response with nisin-loaded pectin NPs treatment [2]. For *Salmonella enterica* and *Listeria innocua* inactivation, 30 kV cm^{-1} electric field in a broad range of pulse parameters (200 ns-500 μs) was used. Increasing the duration of electric pulses leads to better antimicrobial effects of NPs – 300 and 500 μs pulses demonstrates the highest antimicrobial effect against both bacteria strains.

For experiments with magnetic NPs, 10 and 30 kV cm^{-1} electric field pulses (100 μs × 8) were applied separately and in combination with two pulsed magnetic field protocols: high dB/dt 3.3 T × 50 and 10 mT, 100 kHz, 2 min protocol to induce additional permeabilization and local magnetic hyperthermia. We have shown that the high pulsed magnetic fields increase the antimicrobial efficiency of nisin NPs similar to electroporation or magnetic hyperthermia methods, while synergistic treatment is also possible [4,5].

The results of our study are promising for the development of new methods for the treatment of the drug-resistant foodborne pathogens to minimize the risk of invasive infections.

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