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## Usnic acid extracted from *Aspicillia crustose* lichens (UAL) for the preparation of hyaluronic acid (HA) nanoparticles generated from *bifidobacterium* for use in the treatment of diabetes in rats *in vivo*

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Many populations in the world have diabetes. Thus, there is a need for natural compounds that are antidiabetic drugs. In this study, natural compounds were used, including the seed of kiwi (*Actinidia deliciosa*), rhubarb (*Rheum ribs* L.) with the inner membrane of the egg shell, Fleece from the area of Kalkoei (wool of sheep), human fingernail (unguis) and hyaluronic acid produced by the bacteria *Bifidobacterium* with UAL. The natural compounds were divided into 5 groups: A (hyaluronic acid and UAL), B (hyaluronic acid and unguis), C (hyaluronic acid and *A. deliciosa*), D (seed of *A. deliciosa*) and E (Rheum and MIE). The presence of UAL, fatty acids, phytosterols and sesterterpen was confirmed by various techniques, including the use of a Soxhlet apparatus, FT-IR spectroscopy, GC-MS spectroscopy,

and 1H-NMR. Nanocompounds were identified by SEM. The average size of the nanoparticles was found to be 55 nm. We used variables such as pH, different natural compounds, concentration, number of injections, and blood glucose monitoring in different situations. Five groups of nanoparticles were injected into rats, and they reduced their blood glucose levels significantly (statistical significance was declared at  $p < 0.001$ ). The produced hyaluronic acid (glucuronic acid ester with fatty acids) was low molecular weight and helped to treat diabetes in rats. In addition, the chemical structure of the natural compounds looks like those of antidiabetic drugs and could gradually replace synthetic drugs.

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