天然多醣來源外泌體樣奈米囊泡對抗以紫外線誘導皮膚損傷老化之比較研究

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三、蘆薈膠和蘆薈皮衍生奈米顆粒緩解紫外線誘導皮膚發炎能力

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摘要

紫外線為皮膚老化主要外部因素，透過誘導活性氧 Reactive oxygen species（ROS）生成，造成發炎反應與細胞損傷。外泌體樣奈米囊泡 Extracellular Vesicles（EVs）具有傳遞生物訊號與修復功能，在皮膚修復、促進細胞再生及抗氧化方面展現潛力。本研究選用枸杞、蘆薈和桑黃三種富含多醣的樣品，探討其衍生外泌體樣奈米囊泡的分離方法、生物活性與皮膚抗老化能力。枸杞（Lycium barbarum）衍生外泌體樣奈米囊泡（LB-EVs）具茶杯狀雙層結構，平均粒徑約 114.2 nm，具低細胞毒性與高生物相容性，細胞存活率在低濃度下可維持在 90%以上，顯示其作為安全皮膚外泌體介質的潛力。蘆薈膠與蘆薈皮來源奈米粒子 Aloe vera gel and rind-derived nanoparticles（gADNPs 和 rADNPs）可顯著抑制紫外線誘導的 ROS 生成與降低發炎指標 Tumor necrosis factor-α（TNF-α）蛋白表達量和 Transforming growth factor-β（TGF-β）基因表達量，提升細胞抗氧化能力，並具有保護和修復功能。桑黃衍生外泌體樣奈米囊泡 Fungi exosome-like nanovesicles（FELNVs）能有效緩解紫外線誘導的細胞損傷，降低 Matrix metalloproteinase 1（MMP1）表達量，提升 Collagen type I alpha 2 chain（COL1A2）表達量，並降低 ROS 含量、Malondialdehyde（MDA）濃度與 Senescence-associated-β-galactosidase（SA-β-Gal）的表達量，提升 Superoxidase dismutase（SOD）酶活性。且 FELNVs 之 RNA 成分中，miR-CM1 展現顯著抗老化效果，可抑制紫外線造成細胞活性下降，調控光老化基因表達，並提升細胞抗氧化能

力。總結而言，上述多醣來源外泌體樣奈米囊泡具備良好生物相容性與皮膚保護潛力，未來可望應用於皮膚保護和抗老化產品，提供堅實的理論基礎和潛在開發方向。

Comparative Analysis of Natural Polysaccharide-Derived Exosome-Like Nanovesicles in Combating UV-Induced Skin Damage and Aging

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Outline

Abstract

Ultraviolet (UV) radiation is a major external factor contributing to skin aging by inducing the excessive generation of reactive oxygen species (ROS), which trigger inflammation and cellular damage. Exosome-like nanovesicles (EVs) possess signal-transmitting and regenerative properties, showing promise in skin repair, cell regeneration, and antioxidant defense. This study investigated the isolation, bioactivity, and anti-aging potential of EVs derived from three polysaccharide-rich sources: Lycium barbarum, Aloe vera, and Phellinus linteus. Lycium barbarum-derived nanovesicles (LB-EVs) exhibited typical teacup-shaped bilayer structure with an average diameter of 114.2 nm, demonstrating low cytotoxicity and high biocompatibility, maintaining over 90% cell viability at low concentrations, indicating their suitability as safe nanocarriers for skin applications. Aloe vera-derived nanoparticles (gADNPs and rADNPs) effectively inhibited UV-induced ROS production and reduced inflammatory markers (TNF-α and TGF-β), while enhancing antioxidant enzyme activity and promoting cellular protection and repair. Phellinus linteus-derived EVs (FELNVs) alleviated UV-induced damage by reducing MMP1 expression and increasing COL1A2 expression, also decreasing ROS levels, MDA content, and SA-β-Gal activity, while upregulating SOD enzyme activity. miR-CM1, an RNA component within FELNVs, exhibiting better anti-aging effects by preserving cell viability, regulating photoaging-related gene expression, and enhancing cellular antioxidant capacity. In conclusion, three exosome-like nanovesicles demonstrated excellent biocompatibility, antioxidant activity, and protective effects against UV-induced skin aging. These findings

provide a strong foundation in future development of skin protection and anti-aging formulations.

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