Understanding the development of food-grade antibacterial packaging film

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Electrospun films for food packaging remain underexplored yet are considered promising for active delivery and barrier control. This study aims to build zein-based electrospun films with stable fiber morphology and to prepare them for future antioxidant and antibacterial use in food applications. Zein and hydroxypropyl cellulose (HPC) are used as materials for the formation of films that are easy to handle. Meanwhile, phenolic actives such as quercetin (Que) are added to provide films with antioxidant and antibacterial properties.

85% v/v ethanol was used to dissolve total solids, which were composed of a mixture of zein and HPC at mass ratios of 9:1, 8:2, 7:3, and 6:4. Que was added at different concentrations to control the morphology of electrospun fibres and also add antioxidant and antibacterial potential.

The SEM results showed statistical differences across different mass ratios. At a zein:HPC ratio of 9:1, many large beads were observed, and frequent bead collapse was observed. At 6:4, numerous smaller beads were observed along the fiber length. In contrast, ratios of 8:2 and 7:3 were associated with fewer visible defects and more continuous networks. Upon Que addition, existing beads were eliminated at lower concentrations, and the fibres became smoother and more uniform. Moreover, it was also found that as the quercetin concentration increased from 0.5% to 1.5% w/v, the fibers tended to aggregate and form ribbon-like fibers, and beads appeared again and became more frequent. Ribbon or flattened fibers appear when the jet does not dry fast enough relative to stretching. Additionally, the porous structure of electrospun fibers allowed Que to be released in a sustained manner, enabling long-lasting antioxidant and antibacterial effects.

By coupling morphology control with controlled release, a route is created to active films that can protect food quality, limit oxidation and microbial growth, and extend shelf life. The approach is compatible with clean label formulations and low temperature processing, which facilitates translation to scalable packaging formats.

Keywords:
Electrospinning; Electrospun film; Antioxidant; Release control; Antibacterial