Development of Active Packaging Products Based on Natural-Material Nanofiber Composites to Extend the Shelf Life of Food Products

Riset Pengembangan Unggulan 3P

Khairurrijal Khairurrijal[1,3], Dian Ahmad Hapidin[1], Dhewa Edikresnha[1,3], Fenny Martha Dwivany[2,3] , Panji Setyo Nugroho[1], Charlie Ofiyen[1]

[1] Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Jl. Ganesha No. 10, Bandung, Indonesia
[2] School of Life Sciences and Technology, Institut Teknologi Bandung, Jl. Ganesha No. 10, Bandung, Indonesia
[3] Bioscience and Biotechnology Research Center, Directorate of Research and Innovation ITB

Abstract

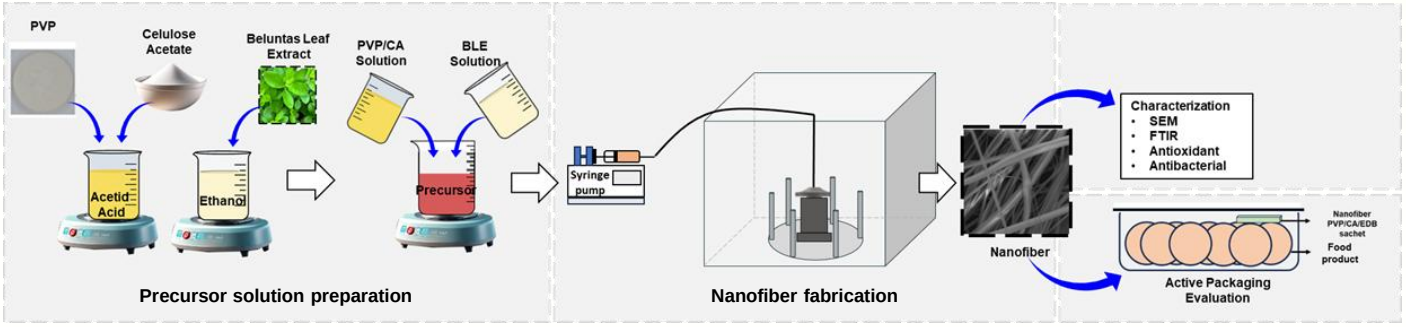
Food spoilage contributes substantially to food loss and waste, highlighting the need for active packaging technologies that can extend product shelf life. This study developed active fibers containing beluntas leaf extract (*Pluchea indica* (L.) Less.) using rotary forcespinning. The extract was incorporated into a polyvinylpyrrolidone/cellulose acetate (PVP/CA) matrix, and the resulting nanofibers were characterized by scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FTIR), as well as evaluated for antioxidant and antibacterial activities. The bioactive potential of the extract was further assessed through component characterization and testing in a food-packaging system. The results showed that PVP/CA formed more stable fibers, while the addition of beluntas extract produced finer fibers than the extract-free PVP/CA matrix. Preliminary food testing also indicated that beluntas extract could slow mold growth during storage. These findings demonstrate the potential of beluntas extract-loaded PVP/CA fibers as an active packaging material to delay food spoilage and help reduce food loss and waste.

Keyword: active packaging, beluntas leaf extract, rotary forcespinning, nanofiber

Introduction

- Food spoilage contributes substantially to food loss and waste. An estimated 931 million tonnes of food were wasted in 2021, while global economic losses reached approximately USD 1 trillion.
- Limitations of conventional preservation methods have encouraged the development of active packaging that uses antimicrobial agents, antioxidants, or scavengers to extend food shelf life.
- Nanofibers are promising matrices for active packaging because of their high surface area, porous structure, and capacity to carry active compounds.
- Beluntas leaf extract (*Pluchea indica*) has antioxidant and antibacterial activities, making it a potential active agent for inhibiting food spoilage.
- This study develops PVP/CA/BLE fibers using rotary forcespinning, which offers a higher production rate and does not require the high voltage used in electrospinning. The fibers are intended for active food packaging that can help reduce food loss and waste.

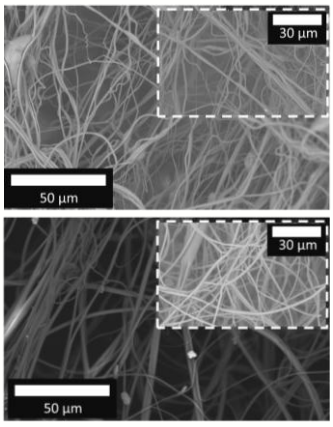
Research Metods

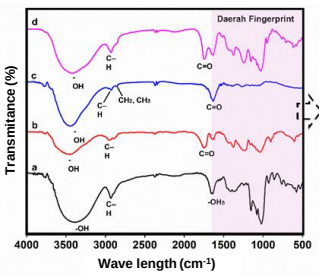


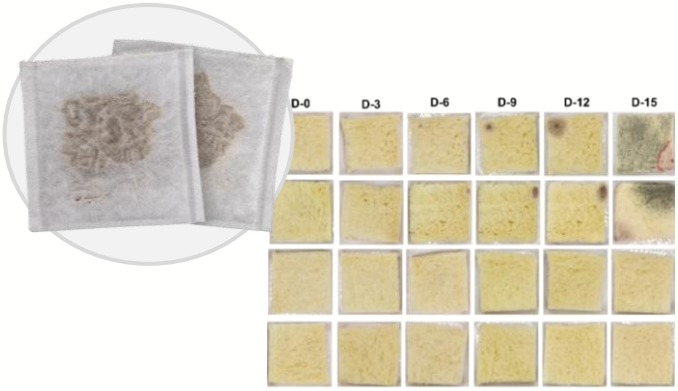
Result and Discussion

Beluntas leaf extract (BLE) at 50 wt% produced the finest and most uniform fibers. At 35 wt%, beads were still present, whereas 65 wt% resulted in particle formation and aggregation. FTIR results supported the incorporation of BLE into the polymer matrix, with a flavonoid encapsulation efficiency (EE) of 51.69%.

PVP/CA/BLE nanofibers increased DPPH radical-scavenging activity by approximately 65% compared with the PVP/CA matrix. Growth inhibition reached 98.51% for Bacillus subtilis and 90% for Aspergillus niger. In the bread-storage test, mold first appeared in the control on day 6, while no visible mold appeared in the PVP/CA/BLE treatment through day 15. This treatment also resulted in the lowest mass loss on day 15, at 7.63%.







Conclusion

PVP/CA was found to be a suitable matrix for rotary forcespinning. PVP/CA nanofibers containing beluntas leaf extract (BLE) show potential for active food packaging. The selected formulation exhibited antioxidant and antimicrobial activities. In bread-storage tests, the nanofibers delayed visible mold growth until day 15 and resulted in the lowest mass loss (7.63%). These findings indicate that PVP/CA/BLE nanofibers are promising active packaging materials for extending food shelf life.