

Upcycling Coffee Waste to Extend Fresh Fruit Shelf Life

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As the global food industry intensifies efforts to reduce waste while extending the shelf life of fresh produce, researchers are increasingly turning to circular, bio-based solutions. A team from UNSW Sydney has taken an innovative step in this direction by transforming spent coffee grounds, one of the world's most abundant food wastes, into a high-performance edible coating for fruits. Led by Lilah Saidi, PhD candidate and lead author of the study "Enhancing the Water Resistance of Carboxymethyl Cellulose Films with Cellulose Nanofibers from Spent Coffee Grounds and Grapeseed Oil," the research demonstrates how cellulose nanofibers derived from coffee waste, combined with grapeseed oil, can significantly improve moisture resistance and preserve fruit quality under ambient conditions. In this interview, Saidi discusses the science behind the coating, its impact on blueberry shelf life, scalability challenges, and how waste valorisation could reshape sustainable food packaging and preservation globally.

What inspired your team to explore spent coffee grounds as a raw material for developing an edible coating for fruits?

Focusing on renewable plant sources for cellulose nanofibers, coffee is a rich source of cellulose nanofibers. Additionally, it is the most traded agricultural product and the second most consumed beverage worldwide. It produces considerable quantities of waste, which increase in proportion to its growing popularity. The inclusion of coffee-origin cellulose nanofibers allowed us

to utilise a component that complies with the film functionality requirements while repurposing food waste.

Could you briefly explain how the cellulose nanofibres and grapeseed oil work together to create a more effective moisture barrier compared to traditional polysaccharide-based films?

The cellulose nanofibers provide dual-purpose performance; As nano-scaled fillers, the cellulose nanofibers fill the gaps within the polysaccharide matrix, reinforcing and forming a cohesive film. As carriers, the cellulose nanofibers retain hydrophobic molecules within the hydrophilic polysaccharide matrix. This dual functionality reduces the affinity and permeability of the coating layer to water molecules.

Your laboratory results show promising improvements in preserving blueberries. What changes did you observe in terms of shelf life, texture, and appearance?

The coated blueberries demonstrated a marked improvement in quality with extended shelf-life under room temperature conditions, which is outstanding as blueberries often require cold storage, while no visual differences between coated and uncoated fruit were observed. It is noteworthy that the coating process does not require washing of the blueberries. This allows preservation of the natural bloom of the fruit with an integrated coating layer.

Many edible coatings face challenges when moving from the lab to real-world applications. What are the key steps and potential hurdles as you transition to testing on fresh fruit and scaling up for commercial use?

It is essential to maintain uniform dispersion of the coating layer on the fruit surface for optimal functionality. As we formulated the coating solution into a consistency that allows the application of either dipping or spraying, optimising the application method on the fruit is one of the challenges to ensure consistent distribution of the coating solution on the fruit surface. Another key factor to scale up this application is to find ways to integrate the process into existing industrial processes while maintaining the required production rate.

Sustainability is a major theme of this innovation. How significant is the impact of repurposing used coffee grounds, and what broader waste-reduction opportunities does this technology open up?

As 1 g of coffee bean produces about 0.9 g of spent coffee grounds, valorisation of this waste allows for the diversion of food waste into functional components. These components are then utilised to prolong the shelf-life of blueberries, further reducing food waste and promoting sustainable practices.

We have demonstrated the embedment of grapeseed oil, a byproduct of wine production. Other food-origin waste constituents can be utilised for various purposes, including edible bioactive components such as antimicrobials.

Looking ahead, do you foresee this coating being adapted for other types of fresh produce, and what would be required to bring it to market in Australia or globally?

With minor adjustments, our technology can potentially be tailored and applied to not only fruits and vegetables, but also to other food products to allow food waste mitigation. The next step of this promising technology is to validate the coating under industrial-scale conditions.

Shraddha Warde

shraddha.warde@mmactiv.com