Could spent coffee grounds provide an alternative to plastic packaging?

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Next to water, coffee is the most popular beverage on Earth and is the world's second most traded good, trailing only oil. It is estimated that humans drink more than 2 billion cups of coffee per day with over 60%

of Americans having a cup each day. As a result, over 8 million tons of spent coffee grounds are disposed of on an annual basis.

What if, instead of ending up in a landfill, those coffee grounds could be used as a sustainable, climate-friendly packaging material?

While this may seem like wishful thinking, a new study from Srinivas Janaswamy, associate professor in South Dakota State University's Department of Dairy and Food Science, has revealed how spent coffee grounds can be made into biodegradable films—material that could one day replace plastics.

The study, titled "Biodegradable, UV-blocking, and antioxidant films from lignocellulosic fibers of spent coffee grounds," was published in the *International Journal of Biological Macromolecules*.

Alternatives to plastic

Plastics are strong, flexible and relatively inexpensive to produce, making them a near "perfect" material for packaging. Plastics, however, pose a serious environmental problem. While recyclable, most plastics end up as litter or in landfills, where they take 700 years to biodegrade. In the oceans, miles of plastic garbage patches—most notably, the Great Pacific Garbage Patch, which is currently the size of Texas and growing—float aimlessly, underlining the growing environmental crisis that an over-reliance on plastic has created.

Of growing concern are microplastics, a relatively new scientific discovery in which microscopic pieces of plastics are finding their way into the food and water that humans consume. Little to no research on the long-term health effects of microplastics on humans has been conducted thus far.

A safe, sustainable and climate-friendly plastic alternative is needed.

"Plastics constitute a wide range of materials designed to meet many daily needs," Janaswamy said. "Replacing all existing plastics is far from possible at this stage. However, substituting low-cost daily commodity-used conventional plastics, which occupy the most considerable fraction of the environmental contaminants, is feasible and can be achieved."

Why coffee grounds?

Over the past few years, Janaswamy has focused his research efforts on creating biodegradable alternatives to plastic, often from agricultural byproducts. Previously, Janaswamy has prepared films from the cellulose-rich peels of avocados and corn stover.

"This project continues my ongoing efforts to prepare films that could replace plastics," Janaswamy said.

Spent coffee grounds were chosen as the source material for a few different reasons. First, spent coffee grounds are widely available with millions of tons produced annually. While most end up in landfills, some are used for other things, like gardening. While this may seem like an environmentally conscious move, as Janaswamy points out, it actually can cause environmental problems.

"Generally, we discard the coffee ground grounds after we make our coffee," Janaswamy said. "Some of us use them for compositing, gardening and other things. Ironically, such a process demands high amounts of oxygen and releases a good amount of methane, which contributes to global warming."

Second, as emerging economies begin adding chain coffee shops—like Starbucks—the amount of spent coffee grounds will only increase. Using

this otherwise unused resource for biodegradable films is a sustainable and economical solution to the plastic crisis.

Finally, spent coffee grounds contain lignocellulosic fibers, the material needed to make the films.

Coffee into film

To prepare the films, the research team first extracted lignocellulosic fibers from the spent coffee grounds. A green chemical modification process was then deployed to make the film more suitable for packaging.

The resulting films were able to biodegrade within 45 days in the soil while also having high tensile strength. Further, the films also had some unique properties of which researchers took note.

"Interestingly, these films could block significant amounts of UV radiation and display antioxidant properties," Janaswamy explained. "I sincerely believe this research outcome opens up new applications for spent coffee grounds."

While this should still be considered "stage one" of turning spent coffee grounds into films, the results from this study showed significant promise.

"The potential for plastic-replacing films from the widely discarded but plentiful and sustainable spent coffee grounds remain unscathed and exciting toward value creation," Janaswamy said.

Sajal Bhattarai, an SDSU graduate and a doctoral candidate at Purdue University, collaborated with Janaswamy on this research.

More information: Sajal Bhattarai et al, Biodegradable, UV-blocking,

and antioxidant films from lignocellulosic fibers of spent coffee grounds, *International Journal of Biological Macromolecules* (2023). DOI: 10.1016/j.ijbiomac.2023.126798