www.scienceinschool.org

Chemistry in a coffee cup: does coffee waste contain key elements for plant growth?

Infosheet 1: The problem of coffee waste

Why should we study coffee waste?

Every day, millions of cups of coffee are brewed around the world and just as many coffee grounds are discarded.[1]

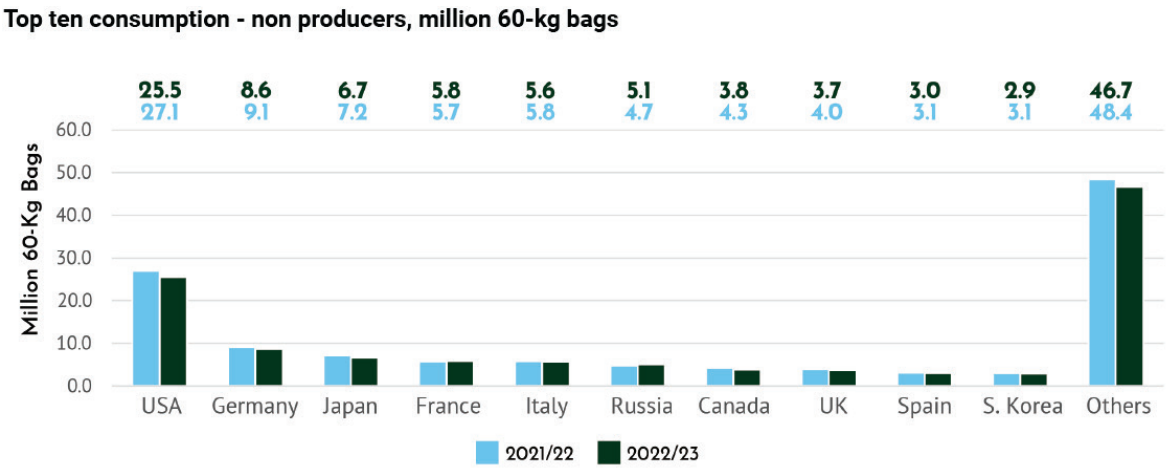

Image taken from Ref. [1]

Spent coffee grounds (SCG) are the residue left after brewing coffee. Although often treated as waste, they are rich in nutrients and organic compounds that make them ideal for reuse in various applications, especially in agriculture and biotechnology.

Source	**Amount of coffee ground waste**	**Equivalent per year**
1 espresso	~7 g	
Home (3–4 cups/day)	~2.5–3 kg/month	~30–36 kg/year
Small café	~5–10 kg/day	~1.5–3.5 tonnes/year

What can SCG be used for?

Chemically, they contain high levels of carbon, nitrogen, and fibre, along with proteins, lipids, and antioxidants such as chlorogenic acids. These properties support their reuse as compost, fertilizers, bioplastics, and substrates for mushroom cultivation.

Chemical composition of SCG (after brewing)

Compound	Approximate content	Function/use
Carbon (C)	45–55%	Organic matter source for compost and soil
Nitrogen (N)	2–2.5%	Essential plant nutrient, supports protein synthesis
Total fibre	~40%	Includes cellulose (8%) and hemicellulose (36%)
Proteins	~10%	Nutritional value, supports microbial activity
Lipids	Up to 16%	Energy-rich, useful in cosmetics and biofuels
Caffeine	<0.5%	Low residual amounts, possible plant growth effects
Chlorogenic acids	~2.3%	Antioxidant properties, useful in cosmetics

Data taken from Ref. [2]

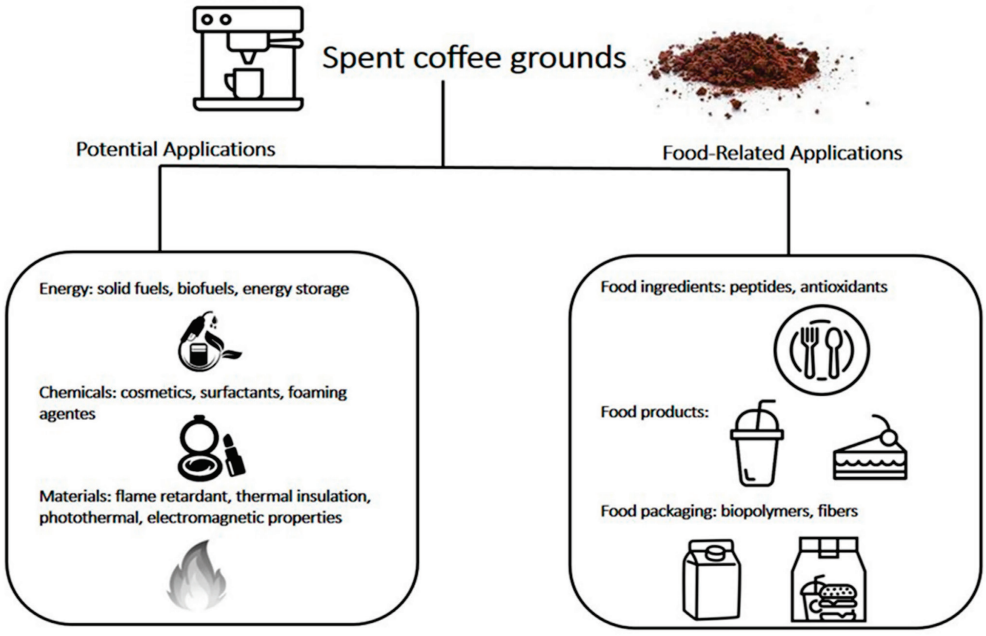

Image taken from Ref. [3]

Why is it important?

SCG often end up in landfill, which causes many environmental problems. Reusing coffee waste helps to recover organic material destined for landfill, in line with the goals of the circular economy. Waste materials are reused rather than wasted, which saves the production of new materials and disposal issues caused by discarded ones.

Student challenge

Can we say that SCG are just waste? Could they be used for something else? What about to provide nutrients for growing plants? Can you measure the key nutrients for plant growth in SCG to find out?

References

[1] A flagship publication of the International Coffee Organization on the circular economy of coffee: https://www.icocoffee.org/documents/cy2024-25/coffee-development-report-2022-23.pdf

[2] Mendes dos Santos et al. (2021) Coffee by-products in topical formulations: A review. *Trends in Food Science & Technology* **111**: 280–291. doi: 10.1016/j.tifs.2021.02.064

[3] Franca AS, Oliveira LS (2022) Potential uses of spent coffee grounds in the food industry. *Foods* **11**: 2064. doi: 10.3390/foods11142064

[4] Pongsiriyakul K et al. (2024) Upcycling coffee waste: key industrial activities for advancing circular economy and overcoming commercialization challenges. *Processes* **12**: 2851. doi: 10.3390/pr12122851