**Spent coffee ground tested as filler for biodegradable composites**

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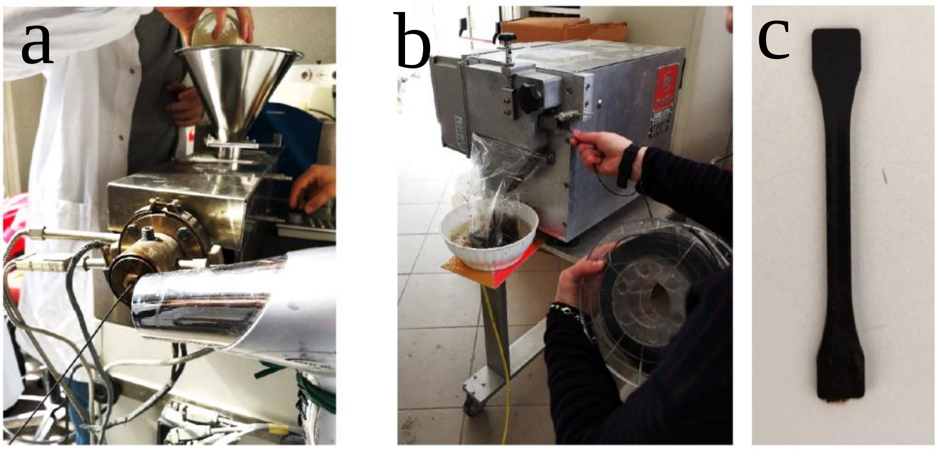
Coffee is one the most widespread and consumed beverage in the world. The amount of spent coffee ground (SCG), the solid residue left after the beverage preparation, is estimated at around 6 million tons per year. Unfortunately, SCG is not readily available as it is spread in small amount in HO.RE.CA. (Hotel, Restaurant, and Cafeterias-Catering) waste, as well as in the organic fraction of domestic solid waste. Despite this intrinsic difficulty in its supply, SCG represents a very interesting source of volatile substances and nutrients, such as sugars, fats, and proteins, as well as of other bioactive compounds, including caffeine, trigonelline, chlorogenic acids, and other phenolics (Mussatto *et al*, 2011; Fan *et al*, 2003).

For these reasons, its reuse and valorization are of paramount importance. In fact, SCG has already been used for some applications, such as biofuel for industrial boilers due to its high calorific power (5000 kcal/kg), a source of fatty acids for biodiesel production, antioxidant material, substrate for mushroom cultivation, and a source of polysaccharides with immunostimulatory activity (Silva *et al*, 1998; Sendzikiene *et al*, 2004; Yen *et al*, 2005; Kondamudi *et al*, 2008). The present study aimed at evaluating spent coffee ground (standard and subjected to acetylation) to be used as a filler for biodegradable composite materials.

SCG, collected from local cafeterias, was first defatted and dehydrated and then subjected to acetylation. The evaluation of the acetylation was carried out by means of infrared spectroscopy with Fourier transform (at C.I.G.S., UniMoRe), by comparison with the control sample. The realization of the master batch was carried out using 222.5 g of polylactic acid (PLA), 2.5 g of paraffin oil (which help improve the adhesion between the filler and the surface of the polymer pellets before extrusion), and 25 g (10% wt) of each kind of SCG. PLA as it is (blank control) and two master batches prepared with standard spent coffee ground (control) and acetylated spent coffee ground were extruded in succession. After thorough mixing, the biocomposites were formed through a twin-screw extruder (557 Rheomex, Haake S.r.l.). The extruded materials (Fig. 1a) were collected in a reel, then granulated (Fig. 1b), and finally processed by injection molding (MegaTech H10/18-1 Tecnica DueBi injection molding machine) in order to obtain specimens (1BA; ISO 527; Fig. 1c) for mechanical and physicochemical characterizations. Mechanical tests on the specimens were carried out through a dynamometer (5567 Instron) and an extensometer (Instron EX2630-107).

Figure 1: From left to right: a) extrusion process; b) injection molding; c) biocomposite specimen.




The control biocomposite had a higher Young's modulus (Table 1) and slightly lower values of maximum traction and break deformation. Despite the derivatization reaction to reduce the polar behavior of OH groups, the biocomposite obtained with acetylated SCG did not show the best performance in the mechanical behavior, indeed Young's modulus, maximum traction, and deformation at break decreased in comparison with the standard SCG (Table 1).

Table 1. Mechanical measurements of biocomposites.
E: Young's modulus; $\sigma_M$ : tensile stress; $\varepsilon$: elongation at break.
PLA: polylactic acid; ncPLA: not subjected to compounding PLA; cPLA: compounded PLA; 10 GS: 10% of SGC (spent coffee ground).

| | **E (MPa)** | **$\sigma_M$ (MPa)** | **$\varepsilon$ (%)** |
|---|---|---|---|
| **ncPLA** | 3389 ± 396 | 62.3 ± 2.0 | 8.6 ± 0.4 |
| **cPLA (blank)** | 3192 ± 570 | 62.5 ± 3.8 | 9.2 ± 0.7 |
| **PLA + 10 SCG (control)** | 3525 ± 273 | 50.6 ± 2.8 | 9.0 ± 1.4 |
| **PLA + 10 SCG acetylated** | 3378 ± 227 | 46.4 ± 2.4 | 6.1 ± 0.5 |

The tested material showed satisfactory mechanical performance using standard SCG. In this way, a 10% reduction in the cost of PLA could be achieved together with an introduction of a rich patrimony of antioxidant compounds that could increase the performance of the biocomposite. At the moment, further investigations should confirm this preliminary experiment.

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