Obtaining high value-added bioproducts from a by-product of the coffee production chain

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There is an urgent need to intensify research on technologies to convert agricultural and/or industrial waste into useful resources for society. Thus, the use of agricultural residues is an emerging field with great potential to boost the sustainable production of chemicals and materials for diverse industrial applications, including polymer synthesis, medicinal uses, and renewable energy [1]. The search for advanced strategies for converting waste into compounds of interest, that is, from co-products with low added value to products with high added value, has been seen to improve the portfolio of companies and the industry in general, since whether they would be generating multi-products from a single raw material [2]. These efforts would necessarily be driven by research based on sustainability principles, since there is no point in converting agricultural waste using polluting technologies. This would only increase the amount of waste, which is the opposite of the desired result [3]. The coffee production chain deserves special attention in this discussion since world coffee production is estimated at 171.9 million bags of coffee beans in the 2020/21 harvest and for Brazil it is estimated a production of around of 47 million bags (1 bag = 60 kg) [4]. In the coming years, with the high production of coffee and the large number of residues generated, it is necessary to find new applications for the reuse of coffee residues, including those produced during the preparation of the coffee beverage. Waste recycling offers many environmental, social, and financial benefits [5]. In this context, coffee, and coffee waste, in cultivation and in its processing, contain large amounts of valuable molecules with high added value, such as polyphenols, polysaccharides, peptides and proteins, among others, which justifies their valorization. Therefore, the practical and innovative use of spent coffee grounds (SCG) and the exploitation of its full potential are urgent, increasing the general sustainability of the coffee agroindustry. Recent studies have demonstrated the viability of waste generated in the coffee chain to produce various products, such as enzymes, phenolic antioxidants, vermicompost, food additives, mushrooms, biogas, biofuels, bioadsorbents, activated carbons, sugars, organic acids, metabolites biologically active secondary compounds, among others, adding value to the product [6].

Brazil is the second largest coffee consumer in the world. According to the Brazilian Coffee Industry Association (ABIC), in 2021, 4.84 kg of roasted coffee were consumed per resident [7]. From the preparation of beverages such as espresso or soluble coffee, or from the extraction of soluble compounds from roasted coffee, whether in the domestic environment or at an industrial level, a solid residue known as spent coffee grounds (SCG) is generated. It is estimated that around 650 kg of grounds are generated per ton of green coffee processed in the industry, and that for each kg of soluble coffee produced, 2 kg of grounds (moisture between 60 and 70 %) are generated [8]. The main components of spent coffee grounds are: 45 to 47% carbohydrates; 13 to 17% protein; 9 to 16% of lipids and phenolic compounds [5, 6]. Spent coffee grounds are one of the most common waste products obtained from coffee shops, restaurants, and snack bars around the world. About 14,000 cups of coffee are consumed worldwide every second, resulting in a total of 22 million kilograms of coffee grounds discarded every year [9]. Coffee grounds have no commercial value and are currently discarded as solid waste or, in some cases, used as fertilizer or burned. Due to its high organic matter content and the presence of compounds such as caffeine, tannins, and polyphenols, which can have negative effects on the environment, disposal of SCG needs to be managed properly. This has encouraged efforts to find ways to reduce its environmental impact and/or transform it into value-added products. The production of biofuels such as ethanol and biodiesel the use as a substrate for growing mushrooms and the use as an adsorbent for removing basic dyes or heavy metals from wastewater are some of the applications. Another promising approach, but still little explored, is the use of SCG as a raw material for the extraction of functional compounds of potential interest for the food and pharmaceutical industries. From the above, it is possible to imagine the potential for reusing SCG. As today this waste goes mostly to landfills and dumps, an alternative destination would avoid the annual emission of tons of CO_2, N_2O and methane into the environment. However, there are logistical and technological challenges. First, it is necessary to collect the SCG and raise awareness about their correct disposal. After that, it is necessary to develop suitable technologies. The preservation of the environment is a constant daily agenda of several companies and organizations. A “green” image has become an important marketing element as customer expectations encourage organizations to reduce the environmental impact of their products [10]. Increasingly, leaders are concerned about seeking sustainable solutions when manufacturing products and providing services. The recovery activity, from the perspective of logistics, represents an increase in the flow of waste, from the consumer to the producer. Thus, the management of this flow is concerned with the flow of waste in the opposite direction to the management of the conventional supply chain. Reverse logistics, for example, is one of the alternatives found to preserve the environment, allowing the consumer to return packaging and waste to the company, so the manufacturer himself is responsible for proper disposal [11]. With the rapid growth of coffee shops that has been taking place in Brazil, a large generation of SCG is inevitable. Reverse logistics then contributes as a solution to overcome this problem. Furthermore, combined with the green concept, it not only increases the value of the SCG, but also improves the quality of the surrounding environment [11]. So, instead of SCG being discarded in the trash, all coffee waste generated by coffee shops and/or industry should be recycled and reintroduced into commerce as new sustainable products, generating profits, and creating businesses and new jobs. Therefore, technologies must be created that allow recycling coffee powder residues and transforming them into advanced biofuels and sustainable biochemicals in the world. In this context, the goal of this work is to show alternatives to produce biofuels, fine chemical products, food, and other products from renewable sources, such as spent coffee grounds (Fig. 1). And it converges with the trend of better use of co-products and by-products, mainly from the agroindustry, with the incorporation of bioproducts production with higher added value to the already established processes, expanding the variety of products in the portfolio, turning the current industries into biomass refineries with minimal generation of solid and liquid waste and atmospheric pollutants. Finally, smart solutions should be implemented to minimize the generation of waste and pollutants and maximize energy efficiency, which will certainly bring about significant socio-environmental contributions. It should be noted that it is essential to have an integral approach to the use of lignocellulosic materials, which will constitute and will be a great advance for science and world industry.

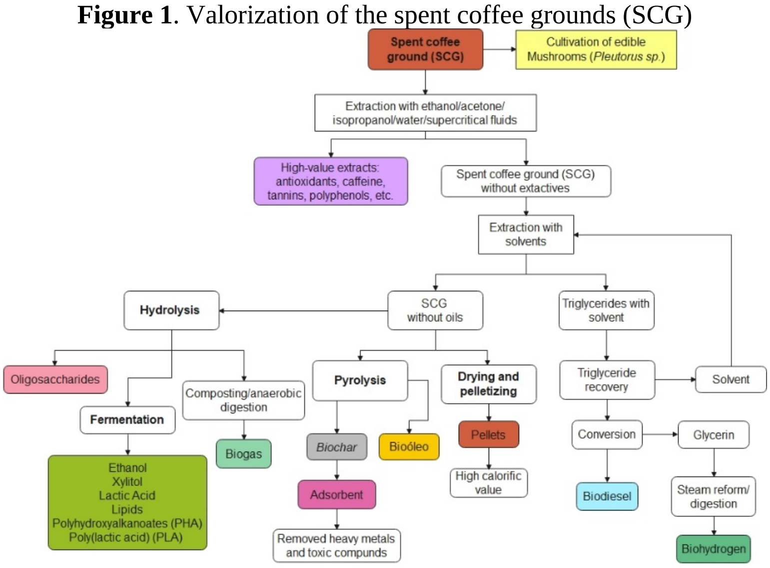

Figure 1. Valorization of the spent coffee grounds (SCG)

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