Development of Technological Routes for Extraction of Bioactives from Coffee Film and Assessment of the Potential of the Phytochemical Profile

Roberto Andrei Santos Borromei[1*], Bárbara Avancini Teixeira[1], Ingrid Lessa Leal[1], Tatiana Barreto Rocha Nery[1], Ana Lucia Barbosa de Souza[1], Fernando Luiz Pellegrini Pessoa[1]

[1]SENAI CIMATEC University Center; Salvador, Bahia, Brazil

The project proposes exploring the potential of coffee skins as a source of valuable compounds due to the excess coffee on the market and the devaluation of prices. Traditionally, the extraction of compounds from coffee skins occurs using methods such as pressing or the use of solvents. However, these methods may have limitations, such as low yield or toxicity. Coffee skin is rich in substances that interest various sectors, such as antioxidants, chlorogenic acids, and dietary fiber. The project seeks to develop coffee skin extraction routes, aiming to increase the yield and quality of the extracted compounds while avoiding their degradation. Furthermore, we intend to evaluate the potential of the photochemical profile of the materials obtained.

Keywords: Technological Routes. Sustainability. Coffee Film. Phytochemical Profile.

In Brazil, research institutions focus on improving coffee agribusiness's productivity, competitiveness, and sustainability, addressing agronomic, genetic, biotechnological, and chemical composition aspects [1,2]. There is a clear need for studies on coffee waste and the sustainability of its production process.

The silver film on coffee, a by-product of its processing, is recognized for its favorable chemical composition and health-promoting properties [3]. Composed of various nutrients, including proteins, lipids, minerals, and bioactive compounds such as polyphenols, this film stands out for its high dietary fiber content, both soluble and insoluble. Furthermore, its extract has demonstrated significant antioxidant activity, offering potential benefits against inflammation, allergies, diabetes, and obesity [3]. The silver film emerges as a promising and sustainable option for several industries. With applications ranging from ingredients in functional foods to substrates for cultivating microorganisms and cosmetics [2].

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Address for correspondence: Roberto Andrei Santos Borromei. Avenida Orlando Gomes,1845, Piatã. Salvador, Bahia, Brazil. Zipcode:41650-010. E-mail:robertoandreisantosborromei@gmail.com.

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In this panorama, the present study aims to identify the industrial potential of coffee film, through effective extraction methods, with greater emphasis on supercritical fluid extraction and ultrasound extraction, thus enabling the use of this residue in the desired industrial areas.

Materials and Methods

A literature review was conducted to identify and understand the extraction processes and essential process optimization factors. Furthermore, a practical comparison between traditional methods and their disadvantages regarding the compounds to be extracted must be carried out.

Nevertheless, laboratory analyses must be conducted to determine the phytochemical composition, including the content of fatty acids, phenolic compounds, and antioxidants.

Results and Discussion

Coffee growing is one of the most important agricultural activities for the Brazilian economy, placing the country as one of the world's leading producers and exporters of coffee.

However, large-scale production generates significant waste that must be managed effectively to mitigate its environmental impact. A promising strategy is reusing this

waste, especially coffee film, through advanced extraction methods [4,5].

Supercritical fluid extraction (EFS) is a technique that stands out for its efficiency in extracting valuable compounds from coffee skins. Using CO_2 in supercritical conditions, EFS allows the selective extraction of antioxidants, chlorogenic acids, and phenolic compounds, which have functional properties beneficial to health. This approach not only maximizes the yield of desired compounds but also minimizes the use of organic solvents and reduces the environmental impact of the extraction process [5]. Conversely, ultrasound emerges as an effective and versatile alternative for extracting compounds from coffee film. This technique uses ultrasonic waves to promote the rupture of film cells, facilitating the release of antioxidants, dietary fiber, and other nutrients. In addition to increasing

Table 1. Techniques for extracting compounds of industrial interest from coffee skins.

Extraction Technique	Compounds of Industrial Interest	Possible Applications	Working Principle
Sohxlet extraction [4]	Caffeine	Use of coffee residues as immunostimulants.	Extraction of the lipid fraction using solvent.
Sohxlet extraction[5]	Cellulose, lignin, hemicellulose	Membrane production for separation process	Extraction of the lipid fraction using solvent.
Aqueous extraction in alkaline medium, microwave radiation [6].	Polysaccharides, Flavonoids, Cellulose	Immune stimulators for the immune system, cellulose for bioethanol production.	Microwave radiation extraction is an extraction method that uses microwaves to heat the solvent and sample, accelerating the extraction process.
Sohxlet extraction [7]	Oily fractions, caffeine	Antimicrobial activity	Soxhlet extraction is a method used to extract compounds from a solid sample using a solvent.
Ultrasound-assisted extraction [8]	Phenolics	Antibacterial activity	Ultrasound-assisted extraction is an extraction method that uses ultrasonic waves to facilitate the transfer of solutes from a solid or liquid matrix to a solvent.
Extraction by methanol, acetone, ethanol [3]	Dietary fiber	Food enrichment, additives in the production of low-calorie cakes.	Solvent extraction is a method traditionally used to extract compounds from a solid or liquid matrix using a suitable solvent.
Aqueous Extraction, Decoction, Infusion [9]	Phenolics, flavonoids	Antioxidant compounds, clusters from wood production.	Decoction extraction is a method of preparing plant extracts that involves prolonged cooking of plant materials in water or another suitable solvent.
Simple extraction [10]	Caramel Color IV	Replacement of artificial colors in the food industry.	Basic separation method used to isolate or purify a substance from a mixture using a suitable solvent.

extraction efficiency, ultrasound reduces the time required for the process. It preserves the quality of the extracts, making it an attractive option for using coffee farming waste [4]. Table 1 lists the most used techniques.

Conclusion

After bibliographical reviews and research into extraction methods that complied with innovation and preservation of the raw material, it was decided to use supercritical fluid and ultrasound extraction. At the same time, it was comparing the efficiency of traditional methods, factors that influence the process, and the quality of the substances. Furthermore, the laboratory analyses to be carried out, focusing on the coffee film, reveal a comprehensive and promising approach to exploiting natural resources sustainably and efficiently. In summary, the search for sustainable methods of extraction and diversified application of coffee and its derivatives highlights their significant role in the economy, industrial innovation, and sustainability.

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