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From Bean To Textiles: Sustainable Production From Coffee And Plastic Waste

Dr. Rafaela Barros[1]*, Dr. Richa Gupta[2]

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Abstract:
This study looks at a creative way to turn spent coffee powder into a useful and sustainable resource for making textiles. With the increased awareness of environmental sustainability and the textile industry's impact on the globe, the study analyzes the viability of utilizing coffee waste, notably coffee grounds and husks, as raw materials for fabric manufacture. The study covers a number of process phases, including fabric development and trash collection and processing. In the first section of the article, the environmental risks associated with conventional textile production techniques are discussed, and the possibility of using coffee waste as a sustainable substitute is emphasized. Setting the stage for the use of coffee waste, the paper discusses previous attempts and accomplishments in using agricultural leftovers for textile applications through a thorough literature analysis. The collecting, processing, and treatment methods used to separate useful fibers and chemicals from coffee waste are described in the methodology section. The impact of several techniques, including mechanical and chemical processing, on the overall sustainability of the proposed fabric production process is examined. The study's findings reveal that it is possible to successfully extract fibers from coffee waste and use these fibers in a variety of textile applications. In addition, the physical and chemical characteristics of the resultant fabric are examined, and its environmental impact, comfort level, and longevity are compared to those of conventional textiles. The study highlights the potential advantages for the textile industry's economy and ecology of using coffee waste on a wide scale. The suggested approach provides a circular economy solution by working with stakeholders in the textile and coffee industries, lowering waste and generating new income for coffee growers.

Keywords*: bio textile; spend coffee grounds; plastic waste; circular economy.*

Introduction

Traditional textiles are frequently made from crops that are high in resources, such conventional cotton, which needs a lot of water, fertilizer, and pesticides to grow. Overuse of these resources can result in degraded soil, a shortage of water, and detrimental effects on biodiversity. Many chemicals are used in the textile production process, such as finishes, coatings, and dyes (Zhou et al, 2022). These compounds can be harmful to ecosystems and human health, and their manufacturing and use add to water pollution. Related to energy consumption, textile factories are major consumers of energy, particularly in processes like spinning, weaving, and dyeing. The reliance on non-renewable energy sources contributes to greenhouse gas emissions and exacerbates climate change (Liu et al, 2021).
At different points during the process, trimmings, offcuts, and discarded materials are among the large volumes of waste produced by traditional textile manufacturing. Getting

[1] *Business School, Humanities Arts & Applied Sciences, Amity University Dubai., https://orcid.org/0000-0002-3100-0316, https://orcid.org/0000-0002-8946-8624,
*Corresponding Author:- Dr. Rafaela Barros
*Business School, Humanities Arts & Applied Sciences, Amity University Dubai.

rid of waste textiles can be difficult, especially if the fibers are synthetic and don't break down easily. Traditional textile production, from the extraction of raw materials to manufacture and shipping, has a significant carbon impact. This covers emissions from manufacturing operations, transportation of raw materials and completed goods, and agricultural machines (Navarro, 2021).

In order to minimize the negative impacts of the fashion industry, in recent years is increasingly exploring and adopting bio-based alternatives as a response to environmental concerns and the desire for more sustainable practices. Instead of relying solely on traditional materials like cotton, polyester, or leather, fashion brands are turning to bio-based alternatives. These can include materials derived from renewable resources such as organic cotton, bamboo, hemp, and lyocell (made from wood pulp). Additionally, innovative materials like mushroom leather (made from mycelium), pineapple leather (Piñatex), and lab-grown textiles (such as lab-grown silk or spider silk) are gaining traction as eco-friendly alternatives to animal-derived materials. In this context, the coffee has been representing an alternative in turned its waste added plastic waste and converting in bio textile (Azam et al, 2023).

Coffee is a unifying force among people worldwide. Approximately 166.63 million 60-kilogram bags of coffee were consumed globally in 2020–2021, ranking it as one of the most popular drinks worldwide. Sustainability expert Gunter Pauli estimates that this generates about 23 million tons of garbage annually. By making clothes out of those coffee, this number can be decreased (Ciardulli, 2021).

Throughout the supply chain, waste of various kinds is produced during the manufacture and consumption of coffee. The following are some important points about wasted coffee; the spent coffee powder are usually thrown away after preparing coffee. But there are other uses for these grounds. Coffee grinds can be used in a variety of inventive ways, such as an organic coffee textile, a natural exfoliate in cosmetic products, and plant fertilizer (Esquivel, 2021).

The protective husk that surrounds coffee beans is peeled off during processing. A sizeable portion of coffee husks are frequently thrown away, even though some are used again as mulch or animal feed. Researchers to produce biofuels and other sustainable materials are using coffee husks (Sugebo, 2022). Large volumes of water are needed for the manufacturing of coffee, and processing effluent may contain contaminants. Eco-friendly processing techniques and water recycling are examples of sustainable activities that can lessen their negative effects on the environment. Coffee packaging, which includes pods and bags, adds to waste. To lessen their influence on the environment, several businesses are implementing eco-friendly packaging solutions like recyclable containers or compostable bags (Padmapriva, 2013).

Coffee cups that are disposable and frequently include a plastic lining add to the trash produced by plastic. To solve this problem, initiatives to encourage the use of reusable cups or the creation of biodegradable substitutes are gaining steam. Cascara, the dried husk of the coffee cherry, is one of the byproducts produced by coffee plants. Cascara reduces waste in the production process and can be utilized to manufacture teas, syrups, and other goods (Arpi et al, 2021). The entire environmental impact of coffee manufacturing is influenced by the energy required for everything from growing to processing and brewing. Reducing this impact can be achieved by employing renewable energy sources and energy-efficient techniques. Waste is produced by unfinished drinks, leftover coffee, and throwaway goods like stirrers and lids in coffee shops and cafés. Promoting the use of reusable cups among consumers and putting recycling systems into place can help address this issue (Murthy and Naidu, 2012).

To reduce waste and its impact on the environment, a growing number of coffee farmers and businesses are implementing ethical and sustainable methods. This includes certifications that encourage social and environmental responsibility in the production of coffee, such as Fair Trade and Rainforest Alliance. The reduction of coffee waste and enhancement of the sustainability of the coffee supply chain are jointly the responsibility of consumers, producers, and industry stakeholders (Bravo et al, 2016).

Globally, the coffee market is expected to earn US$93.2 billion in revenue by 2024. The forecasted compound annual growth rate (CAGR) for this market is 4.41% from 2024 to 2028. Globally speaking, the United States leads the coffee market in revenue generation, expected to reach US$11,440 million in 2024. Consistently the world's biggest producer of coffee, Brazil makes a substantial contribution to the worldwide output. Robusta coffee is produced in large quantities in Vietnam, which has been producing more of it lately. Colombia is one of South America's leading producers of Arabica coffee, which is renowned for its superior quality. Ethiopia is a major producer of Arabica beans and is frequently cited as the origin of coffee. In terms of volume, the globe consumes an astounding 400 billion cups of coffee on average every year, ranking it as the second most popular beverage worldwide behind water. On average, people throughout the world consume 400 billion cups of coffee a year (Coffee Worldwide, 2024).

Coffee waste is frequently seen as an issue, but with the right technologies and long-term waste management techniques, it may be turned into goods with added value. As a pertinent problematic that can be part of the managements techniques, the plastic waste gains strength when it can be combined with coffee waste in order to turned into sustainable goods (Murthy and Naidu, 2012).

This study explores the environmental issues raised by conventional textile production techniques. A large carbon footprint, pollution, and the depletion of resources usually characterize these difficulties. Conventional textile manufacture includes energy-intensive processing, chemical treatments, raw material cultivation (such as cotton or synthetic fibers), and frequently generates significant waste.

Review of Literature

The coffee industry is a global economic sector encompassing the cultivation, processing, trading, and consumption of coffee beans. It plays a significant role in the economies of numerous countries, particularly those in the equatorial regions where coffee is grown.

Overall, the coffee industry is a dynamic and complex sector with economic, social, and cultural significance worldwide. The main key stages of the coffee production and consumption industry involves the cultivation, processing, roasting, trade, distribution, and consumption. Coffee is primarily grown in countries located along the equator in regions known as the "Coffee Belt." Major coffee-producing countries include Brazil, Vietnam, Colombia, Indonesia, and Ethiopia (Morris, 2018).

Coffee: Properties and Reuse

There are two main species of coffee beans: Arabica and Robusta, each with distinct flavor profiles and growing requirements. After harvesting, coffee cherries undergo processing to remove the outer layers and extract the beans. There are two primary methods: the dry process (natural) and the wet process (washed). The method used can significantly affect the flavor and quality of the coffee. The next step the coffee beans are typically roasted before being sold to consumers (figure 1).

Figure 1 *- Coffee rosting process*

Roasting transforms the flavor, aroma, and color of the beans, and different roasting profiles can produce a wide range of tastes, from light, fruity to dark, and bold.

Considering one of the most popular beverages globally, the coffee has a diverse range of preparation methods, including espresso, drip coffee, French press, and cold brew. The consumption is deeply ingrained in many cultures and social rituals, with cafes serving as important social hubs in communities worldwide. The industry continually evolves with innovations in farming techniques, processing methods, brewing equipment, and consumer preferences. Specialty coffee, characterized by high-quality beans, artisanal roasting, and meticulous brewing, has seen significant growth in recent years, driven by consumer demand for unique flavors and experiences (Morris, 2018).

However, in this scenario characterized by large scale production and high consumption the coffee industry faces several sustainability challenges due to its reliance on natural resources, potential environmental impact, and social implications. Coffee cultivation can have significant environmental consequences, including deforestation, soil degradation, water pollution, and loss of biodiversity. In order to mitigate these impacts, sustainable farming practices such as shade-grown coffee, agroforestry, organic farming, and water conservation techniques are promoted. These practices help preserve natural habitats, maintain soil health, and reduce chemical inputs (Lalani, 2024). In additional to those initiatives in order to reduce the negative coffee industry impacts, the collaboration between the coffee industry and the fashion industry are developing ideas and products able to create new products from the coffee waste, as an essential aspect of sustainable resource management and it can significantly reduce the environmental impact of waste disposal for both industries.

The fashion sector is currently accountable for 10% of the world's carbon emissions; if production continues at its current rate, this percentage is expected to increase to 26% by the year 2050. Due to its massive scale and intricate production chains, the fashion industry contributes significantly to pollution. From the procurement of raw materials used to make yarns to the creation of materials, transportation, marketing, and eventual storage and disposal of clothing, there is a lot of pollution involved in the fashion industry. (KIshor et al, 2020).

The production of textiles, both natural (such as cotton and wool) and synthetic (such as polyester and nylon), involves the use of chemicals, water, and energy. Chemicals used in dyeing, bleaching, and finishing processes can pollute waterways and soil if not properly managed. Additionally, textile production consumes large amounts of water, contributing to water scarcity in some regions. Most part of the chemicals inputs for dyeing, printing,

and finishing textiles, including azo dyes, heavy metals, and toxic solvents, can be harmful to human health and the environment. Improper disposal of these chemicals can lead to water contamination and soil degradation (Arshad, 2014).

The high-energy consumption used during all the textiles process, particularly in the production and processing of textiles and garments, consumption contributes to greenhouse gas emissions, exacerbating climate change and air pollution. Additionally, the transportation of raw materials and finished products across long distances adds to carbon emissions.

The fast fashion model, characterized by rapid production cycles and disposable clothing, encourages overconsumption and waste. Consumers are often encouraged to buy cheap, trendy items that are quickly discarded, leading to increased resource extraction, production, and waste generation. This model engaged by the consumer behavior generates a significant amount of waste at various stages of the supply chain, including fabric scraps, offcuts, and unsold inventory. Much of this waste ends up in landfills, where it can take years to decompose and release harmful pollutants into the environment (Suraci, 2021).

With the deepening environmental crisis and the respective impacts, ecofriendly fibers has been developing as it forms the basis of all textiles used in clothing, accessories, and other textile products. As its plays a crucial role in the fashion industry, the choice of fiber not only affects the look and feel of the final product but also its sustainability, durability, and environmental impact (De Oliveira, et al, 2021).

The most fibers commonly used in the fashion industry are natural fibers and syntetic fibers. As part of the natural fibers, the cotton is one of the most widely used natural fibers in the fashion industry. It is known for its softness, breathability, and versatility. However, conventional cotton production can be resource-intensive, requiring large amounts of water, pesticides, and fertilizers. It is often used in summer clothing due to its lightweight and breathable properties. The linen, is made from the fibers of the flax plant and is valued for its strength, durability, and natural luster. Facing the same challenges as the cotton industry, the impact of linear production in the fashion industry refers to the traditional linear model of production, consumption, and disposal, which often leads to environmental degradation, resource depletion, and social issues. The wool is derived from the fleece of sheep and other animals such as goats (cashmere and mohair) and rabbits (angora). (Karima et al, 2021).

As a market trend and life style changes, sustainable wool production focuses on animal welfare and environmental stewardship. On the same market context, the silk is a luxurious natural fiber produced by silkworms and its sustainable production methods, such as peace silk or cruelty-free silk, aim to minimize harm to the silkworms. By prioritizing the use of natural fibers and adopting sustainable sourcing and production practices, the fashion industry can minimize its environmental footprint, conserve natural resources, and contribute to a more sustainable and resilient future. However, as the sustainable practices in natural fibers are still representing a very small proportion of the global natural fiber production, the traditional linear model of production, consumption, and disposal, which often leads to environmental degradation, resource depletion, and social issues (Haverhals, 2020).

When it comes to synthetic fibers, the negative impacts are even more significant when compared to the natural fibers. Synthetic fibers contribute to pollution at various stages of their lifecycle, from production to disposal. The polyester, nylon, and acrylic are the synthetic fiber commonly used in clothing. The Polyester is derived from petroleum. It is widely used in the fashion industry due to its affordability, versatility, and durability. However, polyester production has significant environmental impacts, including greenhouse gas emissions and micro plastic pollution. The nylon is another synthetic fiber

commonly used in clothing, particularly in active wear and hosiery, due to its strength, elasticity, and moisture-wicking properties. Like polyester, nylon production raises environmental concerns. On the same context, the acrylic, synthetic fiber that mimics the properties of wool at a lower cost, its production involves the use of fossil fuels and toxic chemicals (Singh, 2020).

In recent years, there has been growing awareness and demand for sustainable and eco-friendly fibers in the fashion industry. Many brands are exploring alternatives to traditional fibers, investing in research and development of innovative materials, and adopting more responsible sourcing and production practices to minimize their environmental footprint. Facing this scenario, the coffee grounds when add to plastic waste, following a properly and accurately procedure, can represent a sustainable alternative in order to reduce the fashion industry impacts, reusing the plastic waste and giving to the coffee waste a new function.

The plastic waste

Waste plastic refers to any discarded plastic material that has reached the end of its useful life and is no longer needed. Plastic waste is a significant environmental concern due to its non-biodegradable nature, leading to long-term pollution of land, waterways, and oceans. It comes from various sources, including single-use plastics like packaging, bottles, bags, and disposable utensils, as well as durable plastics from products such as electronics, furniture, and automotive parts. Improper disposal of plastic waste, such as littering or improper landfilling, exacerbates environmental problems (Jambeck et al, 2015).

Plastic waste can take hundreds to thousands of years to decompose naturally, causing harm to wildlife, ecosystems, and human health. Additionally, plastics can break down into microplastics, tiny particles that are pervasive in the environment and can be ingested by marine life, entering the food chain and posing risks to human health. Efforts to address plastic waste include recycling, reducing single-use plastics, promoting biodegradable alternatives, implementing waste management policies, and encouraging public awareness and behavioral changes. Governments, businesses, and individuals all play a role in finding solutions to the plastic waste crisis to minimize its environmental impact and protect the planet for future generations (Faraca and Astrup, 2019).

Globally, the production of plastic has been steadily increasing over the past few decades. In 2019, for example, worldwide plastic production reached around 368 million metric tons, and this number was expected to continue rising. The amount of plastic waste generated varies by region, but it's estimated that the world generates hundreds of millions of tons of plastic waste annually. A significant portion of this waste comes from single-use plastics, such as packaging, bottles, and bags (Kumar et al, 2021).

Plastic pollution is a global problem, affecting terrestrial and marine ecosystems alike. Rivers and oceans carry vast amounts of plastic waste, leading to pollution of coastlines and marine environments. Micro plastics, small plastic particles less than 5 millimeters in size, have been found virtually everywhere, including in remote wilderness areas and the deep ocean. The pollution poses serious environmental and health risks. It harms wildlife through ingestion and entanglement, disrupts ecosystems, and can leach harmful chemicals into the environment. There are also concerns about the potential human health impacts of ingesting food and water contaminated with micro plastics (Wu et al, 2017).

Governments, businesses, and organizations around the world are taking steps to address plastic waste through initiatives such as waste reduction campaigns, bans on single-use plastics, improved recycling infrastructure, and research into alternative materials. Recycling, recovery, or energy valorization can be used to extract or create a variety of chemicals, such as lipids, lignin, cellulose and hemicelluloses, tannins, antioxidants, caffeine, polyphenols, carotenoids, flavonoids, and biofuel (Zhao, 2022).

This review will cover the possible applications of waste products from the coffee industry, such as spent coffee grounds from post-consumption, coffee husks, pulps, and silver skin from processing, and coffee leaves and flowers from cultivation. The trash produced by coffee, which comprises both coffee grounds and husks, has the potential to find new uses

when its added to plastic waste. By studying its usage in the manufacture of textile, fashion, and cosmetic items, a multi-faceted approach to waste reduction and resource optimization can be attained.

Coffee and Plastic Waste: A Sustainable Alternative

Coffee grounds are the primary raw material used to make coffee cloth, a technological composite fiber. The fabric derived is quiet similar to viscose and the method of derivation resembles the method of converting bamboo into textiles. The resulting fabric is breathable, light, soft, and flexible which comprises of yarns manufactured from leftover coffee grounds, where the low-temperature, high-pressure, eco-friendly proprietary technique is utilized to make this fabric. Only 4% of the 25 billion kg of discarded coffee grounds produced year are recycled adequately. The remaining 96% decomposes into garbage, which releases the two primary greenhouse gases, carbon dioxide (CO2) and methane (CH4). In addition to being a very popular beverage, coffee has become a way of life. In addition to being a drink, coffee grounds can also be used to make fabric that is used to make clothing (Mirón-Mérida et al, 2021).

Coffee beans are suitable for the production of sportswear due to the unique deodorizing function of coffee grounds. Coffee has a natural ability to prevent odors. When coffee beans are roasted, they expand and the space inside the beans expands. Making coffee with hot water removes any materials that clog these spaces. Coffee fiber fabrics are ideal for sports and activities, as they effectively remove odors. Coffee beans are the preferred choice for making clothes because used coffee grounds release methane, a greenhouse gas 30 times stronger than carbon dioxide (CO2), into landfills. Innovative textile solutions use two environmentally harmful products, coffee waste and plastic water bottles, to produce coffee-based textile (Cibelli, 2021).

There are many companies that are using coffee grounds to produce fabrics, 3D printing, sustainable bio-foam made of coffee oil. Coffee grounds can be used as the ideal ingredient for their screen printing ink. Coffee-infused yarn reduces the quantity of petroleum-based products produced, cuts carbon emissions, requires less energy to create, and keeps coffee waste out of landfills (Rivera et al, 2023).

Coffee grounds are spun into yarn before being used to make clothes. In order to do this, the oils are taken out of the coffee grounds, cleaned, and then powdered into tiny particles. Coffee grounds are processed in a high-pressure, low-temperature atmosphere, in contrast to synthetic fabrics, which are processed in a high-pressure, high-heat environment. After that, the grounds are combined with recycled synthetic material (nylon or polyester) to create a technical fabric that resembles sportswear made entirely of synthetic materials. Both for humans and the environment are harmed by synthetic clothing. Plastic compounds used to make synthetic clothes, such as polyester and nylon, come from crude oil, a fossil fuel. Recall that crude oil is used to make gasoline. Indeed, synthetic materials derived from fossil fuels make about two thirds of our wardrobe. To make matters worse, 85% of material is dumped in landfills, where it will never break down (Laitala et al, 2018).

After outlining the negative environmental effects of typical textile manufacturing, the introduction turns its attention to the possibility of using coffee waste in new ways as a sustainable substitute. This entails taking into account coffee waste as a possible supply of raw materials for the textile industry, such as spent coffee grounds and husks. The objective is to investigate potential ways in which using coffee waste in fabric production could lessen some of the negative environmental effects linked to the manufacture of conventional textiles. This establishes the framework for the paper's later sections, which explore the approaches, findings, and conclusions pertaining to the creative process of turning coffee waste into fabric.

Methodology

By presenting a novel and sustainable raw material made from spent coffee powder, a byproduct of the coffee bean business, the research project aims to convert the coffee powder waste into bio textile. The principal aim is to provide a substitute for conventional textiles, particularly polyester, which presently relies on fossil fuels and exacerbates environmental deterioration. Used coffee grounds release methane, a greenhouse gas 30 times more powerful than carbon dioxide (CO2), as they decompose in a landfill. Innovative textile solutions and fabric made from coffee grounds are made from two environmentally detrimental products: plastic waste and coffee waste.

The recycled fabric is derived from a combination of coffee and plastic waste. Global production of plastic packaging is estimated to be 141 million tons annually. Roughly one-third of all plastic packaging marketed globally leaks from collection systems, causing environmental contamination. These plastics made from fossil fuels are persistent in the environment and decompose slowly. When they do so, they disintegrate into micro plastics, which are easily ingested by fish and other predators and cause bioaccumulation. The basic procedure to obtain the green fiber, is to mix the coffee residue with recycled plastic fibers and re polymerize it, before spinning into a coffee yarn. The yarn contains 5% upcycled coffee grounds and 95% recycled plastic waste derived from plastic packages used in among other things, PET bottles, consumer items, electrical components, and automobile parts. The thermoplastic polymer Polybutylene Terephthalate (PBT) is used to make these containers. Tetrahedron polyethylene (PET) is a member of the polyester family. When stable, it takes on a semi-crystalline structure. It is recyclable and demonstrates resilience to impact, moisture, alcohols, and solvents.It belongs to the category of plastics that are essential to daily living. The textile industry, textiles, and packaging all employ this polymer. It is also utilized in movies to mold parts for electronics, cars, and a variety of other things. These resins are renowned for having a superb mix of characteristics. Dimensional stability and resistance to heat, chemicals, and mechanical stress are some of these qualities (Stylianou et al, 2018).

When polyethylene terephthalate is in its natural state, it is a colorless, highly flexible semi-crystalline resin. Depending on the processing method, it can range from semi-stiff to rigid. It has excellent moisture resistance, alcohol and solvent resistance, impact resistance, and dimensional stability.

The collecting and recycling of waste plastics is the first step in turning them into fashionable textiles. It is an extensive process with many parties involved, such as industries, government agencies, and final customers. Systems of collection to promote proper disposal of garbage. Separating and sorting recyclable plastic from non-recyclable plastic. Processing the waste plastic, which is cleaned, crushed, and made into tiny flakes. The flakes are then melted, combined with leftover coffee grinds, and formed into pellets or chips of resin that are extruded to make spun yarns of coffee polyester for the manufacturing of coffee textiles. Melting the polymer resin and pushing it through a spinneret—a metal plate with tiny pores or orifices—are the steps in the process. Long, continuous filaments are formed when the melted polymer is pushed through the spinneret's tiny holes at high pressure. After that, the filaments are cooled and solidified by being sprayed with cool water or air, or by passing through a cooling chamber. Filaments are drawn—that is, stretched—after solidification in order to align the molecules of the polymers and boost the yarn's strength. After drawing, the filaments are wound onto spools or bobbins for further processing or for use in textile products.

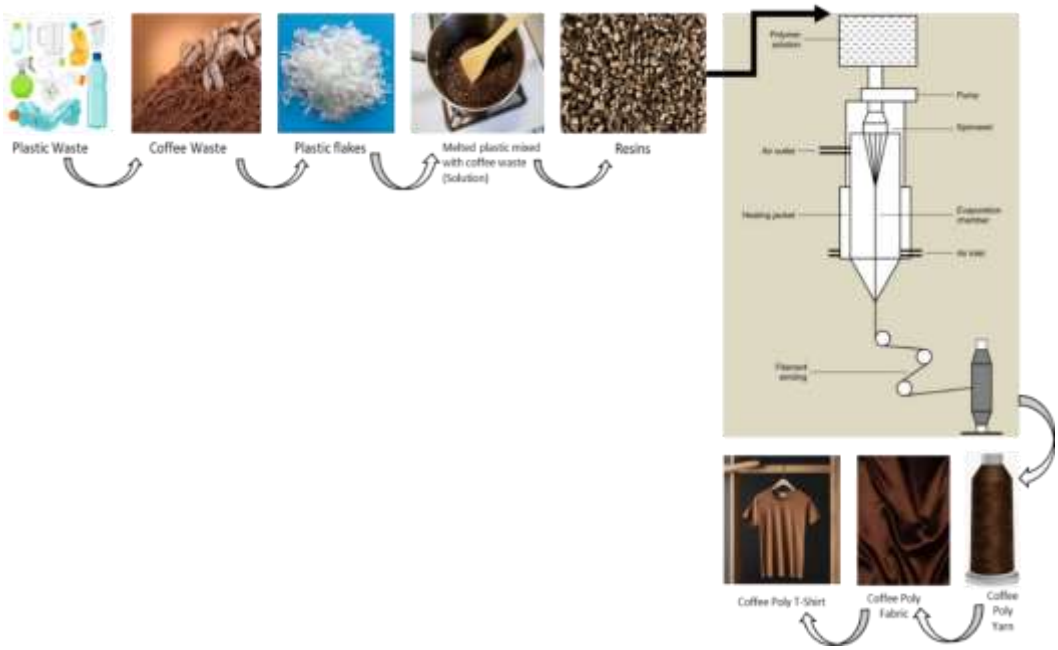

Figure 2 - Creation process of Coffee Textile

Result and Discussion

The manufacture of vegan textiles has become a viable and ecological alternative to traditional liner textile production in the context of the circular economy. A sustainable economic model called the "circular economy" seeks to reduce waste, save resources, and strengthen both the economy and the environment. The circular economy is based on closed-loop systems, which keep materials and resources in use for as long as possible and minimize waste and emissions, in contrast to the traditional linear economy, which takes a "take-make-dispose" approach. It also uses synthetic materials like polyester.

Unlike conventional textiles, using synthetic and natural fibers, which has been promote a unsustainable use of the natural resources causing a global challenge, the vegan textile made of spent coffee powder, can represent an impactful alternative for the conventional textile as the results prove the characteristics and benefits of the final product.

From consumers prospective, studies shows that there is a increase in term of concerned related to about the social and ethical aspects of production, including fair wages, safe working conditions, and respect for human rights. They look for products that are produced ethically and transparently, with consideration for workers' rights and welfare throughout the supply chain.

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ment of natural □bres with synthetics with excellent
performance properties that ruled for another hun-

Waste of spent coffee powder is a byproduct of coffee bean that would otherwise be thrown away are used to make fiber. This indicates that a significant amount of the hundreds of thousands of tons of spent coffee powder can be used to create organic fabrics that are ideal for fashion, casual and luxury field and life-style products.

As a result, the vegan textile produced by the methodology proposed by the present research, show that vegan textile has the potential to be strong and resilient to abrasion. The particular kind and caliber of bio textile utilized determines how long the material will last. The coffee textile can be processed to make them water-resistant or arrive that way naturally. Because of this characteristic, it might be appropriate for some uses where exposure to water is a concern.

Conclusion

Synthetic fibers contribute to pollution at various stages of their lifecycle, from production to disposal. The production of synthetic fibers requires large amounts of water and energy,

further straining natural resources. The manufacturing of synthetic fibers involves the use of petrochemicals derived from non-renewable fossil fuels, such as crude oil and natural gas. The production process can release harmful pollutants into the air, water, and soil, including volatile organic compounds, greenhouse gases, and toxic byproducts. The synthetic fibers shed tiny plastic particles called micro plastics when garments made from materials like polyester and nylon are washed. These micro plastics enter waterways through sewage systems and can accumulate in rivers, lakes, oceans, and soil. Micro plastics pose risks to aquatic life and can potentially enter the food chain, posing risks to human health. (Gupta, R. et al, 2022). The dyeing and finishing processes used in textile manufacturing, especially for synthetic fibers, often involve the use of toxic chemicals and heavy metals. These chemicals can leach into waterways, contaminating freshwater sources and ecosystems and posing risks to human health.

Synthetic fibers are non-biodegradable, meaning they do not break down naturally over time. When clothing made from synthetic fibers is discarded, it contributes to the growing problem of textile waste in landfills. Studies has been proven that it can take hundreds of years to decompose, occupying valuable landfill space and releasing pollutants into the environment as they degrade.

When synthetic garments reach the end of their usable life, recycling options are limited compared to natural fibers. While some recycling technologies exist for synthetic fibers, they are not as widely implemented or efficient as recycling methods for natural fibers. As a result, much of the clothing made from synthetic fibers ends up in landfills, perpetuating the cycle of pollution and waste.

In order to mitigate the various environmental impacts caused by the synthetic fibers industry, efforts are underway to develop more sustainable alternatives, improve recycling technologies, and promote circular fashion initiatives that minimize waste and pollution throughout the textile supply chain. Additionally, consumer awareness and behavior change can play a crucial role in reducing the demand for synthetic fibers and supporting more environmentally friendly alternatives.

For the purpose of minimize those negative impacts and propose an alternative that can provide a new use for the spent power coffee into the fashion industry, the present investigation into vegan textile made from spent coffee powder is a groundbreaking step toward environmentally responsible substitutes in the apparel and textile sectors. The noteworthy advancements in recent times highlight the possibility of vegan textile derived from organic waste as a practical and morally sound alternative to minimize the environmental, social and economic impacts from fashion industry.

From a consumer perspective, sustainability and eco-friendly products are increasingly important considerations in purchasing decisions. Consumers are becoming more conscious of the environmental and social impacts of the products they buy and are seeking options that align with their values. Following the same direction, this research proves that the vegan textile made of spent coffee powder is appealing due to its practical and aesthetically pleasing attributes in addition to its ethical and environmental benefits. The material is a sensible option for a range of fashion and accessory applications because of its proven durability, weather resistance, and versatility. The increased desire for sustainable fashion without sacrificing aesthetics is met by the availability of fashionable and high-quality alternatives, such as bio textile from coffee waste, as customers grow more aware of their ethical and environmental impact.

As this field develops further, it has the potential to redefine industry standards, lessen the negative effects of fashion on the environment, and promote a more balanced relationship between consumption, production, and the environment.

Reference

1. Arpi, N., Muzaifa, M., Sulaiman, M.I., Andini, R. and Kesuma, S.I., 2021, March. Chemical characteristics of cascara, coffee cherry tea, made of various coffee pulp treatments. In *IOP Conference Series: Earth and Environmental Science* (Vol. 709, No. 1, p. 012030). IOP Publishing.

2. Arshad, K., Skrifvars, M., Vivod, V., Valh, J. and Voncina, B., 2014. Biodegradation of natural textile materials in soil. *Tekstilec*, *57*(2), pp.118-132.
3. Azam, F., Ahmad, F., Ahmad, S. and Haji, A.D., 2023. Sustainable Raw Materials. In *Circularity in Textiles* (pp. 59-128). Cham: Springer Nature Switzerland.
4. Bravo-Monroy, L., Potts, S.G. and Tzanopoulos, J., 2016. Drivers influencing farmer decisions for adopting organic or conventional coffee management practices. *Food policy*, *58*, pp.49-61.
5. Ciardulli, M., 2021. *The coffee market: competitive strategies and firm performances in a saturated market* (Doctoral dissertation, Politecnico di Torino).
6. Cibelli, M., Cimini, A., Cerchiara, G. and Moresi, M., 2021. Carbon footprint of different methods of coffee preparation. *Sustainable Production and Consumption*, *27*, pp.1614-1625.
7. Coffee Worldwide. Available at: https://www.statista.com/outlook/cmo/hot-drinks/coffee/worldwide#:~:text=In%202024%2C%20the%20Coffee%20market%20generates%20a%20revenue,in%20the%20Coffee%20market%20with%20US%2411%2C440m%20in%202024. Accessed in 14 feb, 2024.
8. de Oliveira, C.R.S., da Silva Júnior, A.H., Mulinari, J. and Immich, A.P.S., 2021. Textile Re-Engineering: Eco-responsible solutions for a more sustainable industry. *Sustainable Production and Consumption*, *28*, pp.1232-1248.
9. Esquivel, P. and Jimenez, V.M., 2012. Functional properties of coffee and coffee by-products. *Food research international*, *46*(2), pp.488-495.
10. Faraca, G. and Astrup, T., 2019. Plastic waste from recycling centres: Characterisation and evaluation of plastic recyclability. *Waste Management*, *95*, pp.388-398..
11. Haverhals, L.M., Durkin, D.P. and Trulove, P.C., 2020. Natural fiber welding. *Commercial Applications of Ionic Liquids*, pp.211-226.
12. Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. and Law, K.L., 2015. Plastic waste inputs from land into the ocean. *Science*, *347*(6223), pp.768-771.
13. Karimah, A., Ridho, M.R., Munawar, S.S., Adi, D.S., Damayanti, R., Subiyanto, B., Fatriasari, W. and Fudholi, A., 2021. A review on natural fibers for development of eco-friendly bio-composite: characteristics, and utilizations. *Journal of materials research and technology*, *13*, pp.2442-2458.
14. Kishor, R., Purchase, D., Ferreira, L., Mulla, S., Bilal, M. and Bharagava, R., 2020. Environmental and health hazards of textile industry wastewater pollutants and its treatment approaches. 8762v.
15. Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P.K., Kumar, R., Kumar, P., Shubham, Das, S. and Sharma, P., 2021. Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, *13*(17), p.9963.
16. Laitala, K., Klepp, I.G. and Henry, B., 2018. Does use matter? Comparison of environmental impacts of clothing based on fiber type. *Sustainability*, *10*(7), p.2524..
17. Lalani, B., Lanza, G., Leiva, B., Mercado, L. and Haggar, J., 2024. Shade versus intensification: Trade-off or synergy for profitability in coffee agroforestry systems?. *Agricultural Systems*, *214*, p.103814.
18. Liu, J., Liang, J., Ding, J., Zhang, G., Zeng, X., Yang, Q., Zhu, B. and Gao, W., 2021. Microfiber pollution: an ongoing major environmental issue related to the sustainable development of textile and clothing industry. *Environment, Development and Sustainability*, *23*, pp.11240-11256.
19. Mirón-Mérida, V.A., Barragán-Huerta, B.E. and Gutiérrez-Macías, P., 2021. Coffee waste: A source of valuable technologies for sustainable development. In *Valorization of Agri-Food Wastes and By-Products* (pp. 173-198). Academic Press.
20. Morris, J., 2018. *Coffee: A global history*. Reaktion Books.
21. Murthy, P.S. and Naidu, M.M., 2012. Sustainable management of coffee industry by-products and value addition—A review. *Resources, Conservation and recycling*, *66*, pp.45-58.
22. Navarro, A.M., 2021. *An Analysis on the Environmental Impact of the Fashion Industry* (Doctoral dissertation, Massachusetts Institute of Technology).
23. Padmapriya, R., Tharian, J.A. and Thirunalasundari, T., 2013. Coffee waste management-An overview. *Int. J. Curr. Sci*, *9*, pp.83-91.
24. Rivera, M.L., Bae, S.S. and Hudson, S.E., 2023, July. Designing a Sustainable Material for 3D Printing with Spent Coffee Grounds. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference* (pp. 294-311).
25. Singh, R.P., Mishra, S. and Das, A.P., 2020. Synthetic microfibers: Pollution toxicity and remediation. *Chemosphere*, *257*, p.127199.
26. Stylianou, M., Agapiou, A., Omirou, M., Vyrides, I., Ioannides, I.M., Maratheftis, G. and Fasoula, D., 2018. Converting environmental risks to benefits by using spent coffee grounds

(SCG) as a valuable resource. *Environmental Science and Pollution Research*, *25*, pp.35776-35790..

27. Sugebo, B., 2022. A review on enhanced biofuel production from coffee by-products using different enhancement techniques. *Materials for Renewable and Sustainable Energy*, *11*(2), pp.91-103.
28. Suraci, O., 2021. The Best-Dressed Polluter-Regulation and Sustainability in the Fashion Industry. *Hastings Env't LJ*, *27*, p.225.
29. Zhou, Q., Le, Q.V., Meng, L., Yang, H., Gu, H., Yang, Y., Chen, X., Lam, S.S., Sonne, C. and Peng, W., 2022. Environmental perspectives of textile waste, environmental pollution and recycling. *Environmental Technology Reviews*, *11*(1), pp.62-71.
30. Wu, W.M., Yang, J. and Criddle, C.S., 2017. Microplastics pollution and reduction strategies. *Frontiers of Environmental Science & Engineering*, *11*, pp.1-4.
31. Gupta, R., Kushwaha, A., Dave, D., & Mahanta, N. R. (2022). Waste management in fashion and textile industry: Recent advances and trends, life-cycle assessment, and circular economy. Emerging Trends to Approaching Zero Waste, 215-242.