Tracing Fiber Sustainability: A comparative look on organic cotton and MMCFs

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Abstract

This paper presents the complexity of overly simplistic notions of sustainability in fashion, exploring the relationship between fiber production and the environment within the context of consumer misconceptions and unawareness of technological innovation of the industry. It is crucial to address the pervasive cases of greenwashing in fashion, due to misleading environmental language and information of certain fibers, as these hinder genuine efforts towards sustainability. This review aims to understand the different fibers used in the fashion industry through lifecycle assessments, looking closely at the various methods of production and effects of each material. Furthermore, it aims to facilitate more informed decisions and practices on behalf of manufacturers and consumers towards true sustainability. This study closely examines two types of fibers, organic cotton and man-made cellulose fibers (MMCFs), focusing on the case studies of H&M and Patagonia, to understand the challenges and achievements of such materials. Through studies of different fibers, and the brands that embrace them, the paper highlights the diverse ways sustainability is promoted and the overarching issue of misconceptions in fashion. With the numerous complexities surrounding this subject, this paper demonstrates the necessity of understanding the truth behind fashion's processes and looking through the misconceptions many brands place upon consumers.

Introduction

Fashion, a multifaceted industry, has grown as a major global market filled with barriers and opportunities. Underneath this complex system, the foundation of the fashion industry lies in its fiber production. Fiber production encompasses a wide range of materials and resources, each playing a role in the unique properties and applications of today's clothing. The array of materials used most commonly in fashion's textiles can be broadly divided into two categories: synthetic and natural fibers. Synthetic fibers, a technological innovation at the time of development in the 1930s, ought to provide an alternative to natural fibers for its desirable properties and efficiency in production. Yet despite that, over the years, synthetic fibers have accounted for several environmental issues, including the shedding of microfibers that contribute to microplastic pollution. Though synthetic fibers are durable and cost efficient, the effects of such fibers are detrimental, including an estimated 22 million tons of microfibers emitted in marine environments by 2050.[1] On the other hand, natural fibers have been coined as more environmentally friendly types of textiles, with a common misconception that "organic fibers" are inherently better for the environment. However, the reality of this is much more complicated, as the cultivation of natural fibers uses a substantial amount of water, chemical fertilizers and pesticides, leading to soil degradation and water pollution[2]. With the growing concern over such environmental impacts, the industry faces an increasingly prominent debate

[1] S. Raja Balasaraswathi and R. Rathinamoorthy, "Synthetic Textile and Microplastic Pollution: An Analysis on Environmental and Health Impact," in *Circular Economy and Microplastic Pollution,* ed. Subramanian Senthilkannan Muthu (Singapore: Springer, 2022), 1-20.

[2] M. Meier et al, "Environmental impacts of organic and conventional agricultural products--are the differences captured by life cycle assessment?" *Journal of environmental management,* vol. 149 (2015): 193-208, https://doi.org/10.1016/j.jenvman.2014.10.006.

over the most sustainable fiber choices, often dividing between synthetic and natural fibers. As increasing sustainable fashion movements urge for new initiatives and more responsible production practices, this paper addresses the issues associated with certain fibers and further explores innovative alternatives for the future of fibers in the fashion industry.

Driven by the numerous concerns over fashion's environmental footprints, the sustainability trend in fashion has emerged to meet with consumers' demands of more responsible production practices and products. However, sustainability and this overall trend is embedded with lack of accurate information. One example of misinformation in sustainable fashion lies in the idea that natural or organic fibers are equated to sustainability, often overlooking the true costs of cultivating these "organic" fibers, including intensive water usage and soil erosion. Moreover, shaped by consumers' demands for sustainable fashion, manufacturers and brands have begun to place emphasis on their sustainability profiles, often resorting to greenwashing - the making of false claims about the environmental impacts of a product.[3] The branches of misconceptions and misleading claims within the fashion industry underline complexities of sustainability and the importance of having an understanding on the issues, such as waste pollution, associated with it. This paper aims to unravel the complications of fiber sustainability in fashion by revealing common misinformation and assessing environmental implications of natural fibers and other sustainable alternatives. However, before closely examining the fibers, it is crucial to grasp the understanding of what sustainable fashion really is and the roles of materials and fibers in the industry to set the big picture. The paper then follows by introducing the innovative developments that were made in response to the sustainability movement so that differences can be made in comparison with traditional types of fibers. The paper also includes two case studies of different companies – H&M and Patagonia - with differing sustainable profiles to help gain a more comprehensive understanding of the relationship between production and sustainability.

Part 1: Defining Sustainability in Fashion

Sustainability does not have a confined definition in fashion; instead, it is a term used to broadly describe the processes of production and design that are "environmentally and/or ethically conscious."[4] The fashion industry, over the years of mass production and waste generation, has become one of the largest industries and polluters in the world.[5] Problems surrounding this industry root in each stage of the production process, including an increase in pollution and a strain on natural resources, in addition to poor health of workers. These concerns have gained an increasing level of awareness about the issues with the environment and society, contributing to the rise of popularity with the sustainable fashion movement. With the rapid pace of fashion and the constantly changing trends that cause short-lived and easily disposable clothing, this movement has encouraged many initiatives to repair some of the damages associated with the

[3] K. Becker-Olsen and S. Potucek, "Greenwashing," in *Encyclopedia of corporate social responsibility*, ed. Samuel O. Idowu (Berlin: Springer, 2013), 1318-1323.
[4] J. Farley Gordon and C. Hill, *Sustainable Fashion: Past, Present and Future* (New York: Boomsbury Publishing Plc, 2014), XV, http://ebookcentral.proquest.com/lib/ucsd/detail.action?docID=1779016.
[5] S. Shafie et al, "Fashion Sustainability: Benefits of Using Sustainable Practices in Producing Sustainable Fashion Designs," *International Business Education Journal*, 14(1): 103-111, https://doi.org/10.37134/ibej.vol14.1.9.2021.

industry. Solutions towards a greener future for fashion are becoming more and more necessary with the current pace of the trend cycle, and they are further promoted by a large audience, such as environmentalists, businesses and consumers. Nonetheless, it is essential to note that even with all the possible initiatives taken, sustainability in fashion can never reach one hundred percent.[6] However, this should not lessen the efforts towards achieving sustainability, and rather further research and understanding on the topic should be encouraged to move towards increased sustainability.

Part 2: Evaluating the Major Fiber Categories

Understanding that issues regarding the fashion industry are embedded in each production process and that fiber cultivation is the foundation for clothing production, it is necessary to grasp an overview of the major fiber categories to see their relations with the environment and sustainability. With the growing trend of sustainable fashion along with the growing demand of clothing, conversation sparks over fiber choices in fashion. As referenced previously, the two major fiber categories, synthetic and natural, are the most commonly seen materials in today's garments worldwide, with cotton and polyester making up ¾ of the market share of each fiber type in the fashion industry.[7] However, numerous problems are associated with the two types and neither one of them seem to be a perfect solution towards sustainability. Synthetic fibers, such as polyester, can be manufactured in a cost and time efficient manner, but their microfiber properties harm the environment significantly, negatively impacting marine ecosystems. Natural fibers, such as cotton, even if produced more sustainably, cannot meet the global demand for clothing as it requires a significant amount of water, leading to water depletion and ecosystem harm. Moreover, natural materials like cotton often lack the properties of synthetic fibers, such as elasticity and durability.[8] Because of these problems, neither of the fiber choices seem like suitable options to replace with one another.

Part 3: Introducing Man-made Cellulosic Fibers

As a result of the unsustainable fiber choices used in the industry production, many have opted for other innovative alternatives that provide all the necessary properties. Man-made cellulosic fibers (MMCFS) is an example of one of the most promising sustainable fibers. MMCFs, an innovative development using regenerated cellulose for fiber cultivation, can be classified into two types: conventional feedstocks, which require the use of wood pulp, and alternative feedstocks, which use non-wood or recycled plant materials.[9] This new source of technology is said to potentially compete against the current two major fibers, polyester and cotton, highlighting the potential opportunities MMCFs can provide for the growing demand for sustainability. The process of harvesting these fibers involves the use of recycled content and renewable sources, which benefits the environment and helps reverse some of the impacts that natural and synthetic fibers leave. Nevertheless, just like any other fiber sources, at this time

[6] Gordon and Hill, *Sustainable Fashion: Past, Present and Future*.
[7] C. Drahl et al, "The future of sustainable textiles," *Discovery Report* Q2 (Washington DC: American Chemical Society, 2022).
[8] R. M. Frazier et al, "Beyond cotton and polyester: An evaluation of emerging feedstocks and conversion methods for the future of fashion industry," *Journal of Bioresources and Bioproducts*, 9(2) (May 2024): 130-159, https://doi.org/10.1016/j.jobab.2024.01.001.
[9] Frazier et al, "Beyond cotton and polyester."

MMCFs still have limitations in their production, such as emissions of harmful chemicals and waste degradation issues that obstruct the efforts put in towards sustainability.[10]

Part 4: The Importance of Cotton and MMCFs

With an overview of all major fiber categories, this paper dives deep into two specific fibers, cotton and lyocell, to address the misinformation and interest of "sustainable alternatives." As the issue with misconceptions over natural fibers become prevalent with the use of cotton in clothing, it is important to recognize the reality of such fiber and the effects it has on the environment. It is crucial not to be misled by inaccurate language, such as "organic" or "natural," which often evokes eco-friendly ideas. The comparison of cotton is made with lyocell, a MMCF material, to highlight how traditionally perceived organic fiber differs from an actual innovative alternative, and to further understand the restrictions and opportunities the two fibers offer. The paper compares the two materials through a system known as life cycle assessments (LCAs). This system of assessment considers all processes of the supply cycle, surveying the environmental impacts of the material at each stage of production. It looks at the raw material extraction, textile manufacturing, transportation, consumer use, and end of life stages of each fiber. This assessment also inspects closely on all substages, like packaging and distribution, of production to ensure a thorough evaluation of the environmental footprints of the fiber.[11] Through the assessments of cotton and lyocell, this research aims to provide a more in-depth comprehension of the different fibers and their impacts on the environment.

Part 5: A Closer Look at H&M and its "Conscious Collection"

As a result of the increasing environmental awareness and demand for sustainability among consumers in fashion, many brands have been actively promoting their ostensible green products and sustainable profiles. Unfortunately, many of these claims often mask the reality behind production, including the negative environmental impacts made.[12] H&M serves as an example for a brand that partakes in such cases of greenwashing, as seen in their 2011 case of the "Conscious Collection." Despite H&M being the second largest retailer and top clothing contributor to environmental pollution in the world, the brand has continued to advertise its efforts towards sustainability.[13] The launch of this "Conscious Collection" was seen as an attempt for the company to appeal to the growing demand for environmental awareness. In the course of this collection, images of nature, including greeneries and skies, were often seen as backdrops for advertisement campaigns, further highlighting H&M's marketing efforts to convey their environmentally friendly messages.[14] Furthermore, the company's website page for this "Conscious Collection" campaign stated their criteria for a product to be considered "conscious"

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[10] M. Shabbir and F. Mohammad, "Sustainable production of regenerated cellulosic fibres," in *Sustainable Fibres and Textiles*, ed. Subramanian Senthilkannan Muthu (UK: Woodhead Publishing, 2017), 171-189.
[11] V. Gonzalez, X. Lou and T. Chi, "Evaluating Environmental Impact of Natural and Synthetic Fibers: A Life Cycle Assessment Approach," *Sustainability* 15(9):7670 (2023).
[12] S. Linckens, C. Horn and J. K. Perret, "Greenwashing in the Fashion Industry – The Flipside of the Sustainability Trend from the Perspective of Generation Z," *ISM*, no. 23 (2024).
[13] O. Lai, "7 Fast Fashion Companies Responsible for Environmental Pollution," *Earth.Org*, October 15, 2022, https://earth.org/fast-fashion-companies/.
[14] Linckens, Horn and Perret, "Greenwashing in the Fashion Industry."

includes “at least 50% sustainable materials, such as organic cotton and recycled polyester.” [15]However, the requirements for the products alone stir several issues.

First, each item of clothing only has to contain 50% of sustainably sourced materials to be labeled as “conscious,” leaving the other 50% neglected. This raises concern over the fact that toxic or synthetic materials, that are non-biodegradable and shed microplastics, can be used in 50% of the fabric included in the collection.[16] Second, the company’s claims of recycled polyester and organic cotton as examples of sustainable materials can be inaccurate and misleading. Even if recycled polyester is a “recycled” source of fiber, the material is still synthetic and, when washed, will still shed microplastics that end up in natural environments.[17] Moreover, the frequent advertisement for organic cotton is often incorrectly associated with sustainability and its complex environmental impacts are overlooked. Thus, it is necessary to analyze the life cycle of organic cotton to truly understand the sustainability of H&M’s collection.

Cotton, though being the second most used source of material in fashion that is known for its comfort and strength properties, is commonly associated with several environmental issues, especially within the conventional cultivation and production of this fiber.[18] Conventional cotton uses excessive amounts of water and pesticides to grow, leading to numerous environmental problems worldwide.[19] As a response to this cotton crisis, organic cotton was introduced in the industry as a more sustainable option, banking on its minimal water and pesticide usage. The organic cotton certifications, such as the Organic Content Standard, further perpetuates the idea of organic cotton being a cleaner and preferred choice of fiber. However, while organic cotton is referred to as a more sustainable alternative to conventional cotton, the use of this fiber is controversial and often subject to greenwashing claims.[20] Though LCAs of organic cotton show that water and energy consumption, as well as soil damage, is significantly reduced when compared to conventional cotton, there are still some limitations within the assessment methodology.[21] Moreover, in terms of crop yield, it is important to note that organic cotton

[15] “Conscious – Sustainable Style,” Sustainability, H&M, accessed June 26, 2024, https://www2.hm.com/en_hk/men/shop-by-concept/conscious.html.
[16] Linckens, Horn and Perret, “Greenwashing in the Fashion Industry.”
[17] L. Tonti, “How green are your leggings? Recycled polyester is not a silver bullet (yet),” *The Guardian*, March 21, 2021, https://www.theguardian.com/fashion/2021/mar/22/how-green-are-your-leggings-recycled-polyester-is-not-a-silver-bullet-yet.
[18] D. Gopalakrishnan, “Organic Cotton – an overview,” *Fibre2Fashion*, February, 2007, https://www.fibre2fashion.com/industry-article/1584/organic-cotton-an-overview.
[19] Gopalakrishnan, “Organic Cotton – an overview.”
[20] P.J. Wakelyn and M.R. Chaudhry, “Organic cotton: production practices and post-harvest considerations,” in *Sustainable Textiles*, ed. Richard Blackburn (Woodhead Publishing, 2009), 231-301.
[21] “Organic Cotton Market Report,” Textile Exchange, last modified March 8, 2022, https://textileexchange.org/knowledge-center/materials/organic-cotton-market-report/?gad_source=1&gclid=CjwKCAjw2dG1BhB4EiwA998cqCXyv5dUDCslmvjchhz-v78htaJagZkO0kjC8ZlOGiqVmfrydGSNBhoCNn0QAvD_BwE.

production is not as efficient as conventional cotton and actually provides a lower yield.[22] Therefore, more organic cotton crops will have to be planted to sustain the same amount produced by conventional cotton crops. This means extra land will have to be used to obtain organic cotton, requiring more consumption of water and soil, further reversing the efforts made to bring sustainability.

Cases like organic cotton, where the supposedly sustainable fiber lies in complex environmental issues, are becoming increasingly prevalent in the fashion industry. This highlights a significant problem of greenwashing as misconceptions are exacerbated by misinformed marketing and false environmental language. Companies, like H&M, using terms such as “organic” or “recycled” often bring a false sense of environmental responsibility or benefit to the consumers without addressing the complicated factors involved in production. The promotion of organic cotton is an example of how the negative environmental impacts are downplayed, resulting in misconceptions among consumers about the truth of their clothing. Though organic cotton does reduce some of the harmful impacts that conventional cotton leaves, the other environmental factors, such as intensive land use, should not be discredited. It is important for brands to provide transparency surrounding their production, as practices of greenwashing not only misinform consumers, but also obstruct the attempts to move towards a more sustainable goal in the industry.

Part 6: An Analysis of Patagonia’s Sustainability

As fast fashion brands continue to promote inaccurate claims of their sustainability profiles, many other companies have emerged with genuine initiatives towards sustainability. In comparison to H&M, Patagonia serves as an example of a brand with a more reliable approach towards a cleaner future for fashion. Unlike fast fashion brands’ misleading advertising and vague product information, Patagonia has been long recognized for its sustainable products globally.[23] The brand marketing strategies emphasize their sustainability commitment and transparency, offering substantial amounts of information on the product sourcing and production. Their websites provide detailed and extensive explanations of their products in an effort to educate consumers about the opportunities and restrictions of their sustainable practices, differentiating themselves from large corporations, like H&Ms, and the broad claims made about their products. Patagonia promotes its sustainability values through a course of initiatives and campaigns, such as the 2011 “Don’t Buy This Jacket” campaign, where they discouraged consumerism and encouraged consideration of clothing’s environmental impacts, as well as the 2013 “Worn Wear” campaign, which encouraged consumers to send their worn-out Patagonia clothing for repair.[24] Beyond the brand’s actions within their environmental

[22] “Comparing Conventional and Organic Cotton Production,” Cotton Incorporated, accessed June 26, 2024, https://cottontoday.cottoninc.com/wp-content/uploads/2020/07/Cotton-Incorporated-Fact-Sheet-ConventionalOrganic_Final-Approved_06.25.20.pdf.

[23] C. Schillmann, “Patagonia Inc. under a sustainability perspective,” (Student Paper, Nottingham University Business School China, 2020).

[24] Patagonia’s campaign was a clever strategy to bring more awareness to the brand and the overarching issue. F. Szekely and Z. Dossa, “Patagonia’s sustainability strategy: Don’t buy our products,” *IMD* (December, 2015).

activism campaigns, Patagonia has also contributed to their sustainability goals through fiber innovation, specifically their use of MMCFs, like lyocell. Mentioned on their website, Patagonia states their use of lyocell in their products and their stance within the use of MMCFs in production. The brand recognizes potential issues and limitations associated with the use of MMCFs, such as use of tree pulps that link to deforestation, and addresses that their MMCF fibers are sourced sustainably from grown wood or waste streams. Patagonia's efforts towards sourcing and advancing fiber materials with MMCF not only support their brand message of sustainability, but also bring awareness to the development of such MMCFs. Therefore, it becomes essential to analyze MMCF materials, such as lyocell, to grasp a better and more accurate perception of the fiber.

MMCFs are acquired from cellulose, which is known as the main compound within plant cell walls.[25] Through various cultivation processes, this compound is broken down and then constructed into an array of fibers with desirable properties.[26] In Patagonia, lyocell is a major MMCF material used in the production of their clothing, notable for its stretch and high absorbency qualities.[27] Lyocell, or known by its brand name, Tencel, is derived from wood pulp which is then manufactured to become the fabric used in clothing. Life cycle assessments of lyocell show the sustainability of the fiber, highlighting its usage longevity and sustainable end-of-life stage. As lyocell clothing lasts a long time, this fiber sets itself apart from the other fibers used in fast fashion brands. The long-lasting quality stands as a more sustainable option than the poor quality used in the race of rapidly changing fashion trends. Furthermore, these MMCF fibers, like lyocell, are biodegradable and reusable, providing an environmentally friendly end of life alternative.[28] With these qualities, MMCFs make a good alternative to traditional fibers and align with Patagonia's aim for a better environmental footprint.

However, as mentioned in the overview, full sustainability can never be reached, and no fiber is a perfect solution. Many MMCFs are sourced from wood, which if cultivated repeatedly, can lead to deforestation and more negative ecological effects. It is also important to consider the transportation and manufacturing stages of these fibers, which are heavily energy intensive, which can further exacerbate environmental impacts.[29] Therefore, while MMCFs, like lyocell, seem like a promising choice of fiber to the future of fashion, they currently hold several limitations to achieving full sustainability. Even though Patagonia's efforts towards this goal seem genuine, it is important not to quickly assume the truth behind the brand and the mission. On Patagonia's website, mentions of recycled polyester were still seen in their material

[25] Frazier et al, "Beyond cotton and polyester."
[26] "Man-Made Cellulosic Fibers," Patagonia, accessed July 4, 2024, https://www.patagonia.com/our-footprint/man-made-cellulosic-fibers.html#:~:text=At%20Patagonia%2C%20we%20source%20MMCFs,sacrificing%20product%20quality%20or%20performance.
[27] "Man-Made Cellulosic Fibers," Patagonia, accessed July 4, 2024, https://www.patagonia.com/our-footprint/man-made-cellulosic-fibers.html#:~:text=At%20Patagonia%2C%20we%20source%20MMCFs,sacrificing%20product%20quality%20or%20performance.
[28] Q. Nguyen, "How Sustainable Are Lyocell Fabrics? A Life-Cycle Analysis," Impactful Ninja, accessed July 4, 2024, https://impactful.ninja/how-sustainable-are-lyocell-fabrics/.
[29] Nguyen, "How Sustainable Are Lyocell Fabrics? A Life-Cycle Analysis."

sourcing, which were discovered to still have negative impacts.[30] Although Patagonia's practices and initiatives seem completely different from H&M's advertised actions, these fiber instances show how two contrasting brands can share the same struggles. In the long term, MMCFs will have to continue their innovation and development of the best practices.

Conclusion

As sustainability becomes a rising topic of discussion in recent years, many efforts have gone into finding solutions for the environmentally problematic fashion industry. Concerns over pollution and waste generation have all prompted awareness and consumer demands for change. This paper explores the complex relationship between the sustainability trend and fibers, a significant factor of fashion's production. Diving into the research of fibers in fashion, several environmental challenges are found in the extensive layers of textile production, such as microfiber shedding of plastic with synthetic fibers and water and land depletion with natural fibers. With the examinations of such issues, this research also introduces the innovative opportunities of sustainable textiles, such as man-made cellulosic fibers, that aim to contribute to the sustainability efforts. However, through close case studies of different brands, such sustainable alternatives are found to still face significant limitations regarding their environmental footprints. Organic cotton, although more sustainable than conventional cotton, is often overlooked for its numerous effects on surrounding environments. MMCFs, seen as innovative and promising alternatives to traditionally used fibers, still require extensive research regarding their complete sustainability. Nonetheless, with the rise of consumers demanding for sustainable fashion, brands are still trying to adopt more environmentally responsible practices. Although this trend has benefited fashion's role in the environment, it has also led to a proliferation of greenwashing. Greenwashing claims of certain fibers often overlook the reality of such materials, misleading consumers and their trust, and further underscore the intricate relation of sustainability trends with fiber production. This paper hopes to present the necessity in gaining an understanding of fashion and its production processes. It also hopes to help consumers look beyond common misconceptions placed upon them.

Looking forward, sustainability will continue to become an important topic for consumers and brands and further emerges as a necessary move for the future of the environment. In Brittany Sierra's article from *The Sustainable Fashion Forum*, there are six themes mentioned that will shape the future of sustainability in fashion. The first theme follows with collaborations to scale next generation materials, focusing on the need to use innovative materials and highlighting the limitations with scaling the supplies. The second theme is greenwashing, which is already seen in brands like H&M that faced challenges with the authenticity of their claims. Next, garment worker activism and brand accountability, which focus on the ethics of brands' worker standards. Another theme predicted of sustainable fashion's future includes investment in technologies that support transparency, supporting the use of technologies like the Digital Product Passports that offer deep understanding of products. Lastly, an emphasis on repairs, which underlines the benefits of offering such services to consumers.[31] Many of these themes are already seen in this

[30] "Materials," Patagonia, accessed July 4, 2024, https://www.patagonia.com/materials/.
[31] B. Sierra, "6 Themes That Will Shape the Future of Sustainability in Fashion in 2024," The Sustainable Fashion Forum, last modified January 4, 2024, https://www.thesustainablefashionforum.com/pages/6-themes-shaping-sustainable-fashion-in-2024.

paper's discussion regarding fiber construction and greenwashing, suggesting the importance of this paper's concerns in alignment with the future of fashion. Such trends shaping sustainability in fashion put an emphasis on the urgency for change. Yet, with so many restrictions involved in the industry's fiber production, this paper advocates for continued innovation and research towards sustainable efforts and further encourages more ideas and actions that correspond with these future themes.

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