Technik & Architektur
HSLU Lucerne University of Applied Sciences and Arts

EAP Semester Performance 1

Herbstsemester 2024

$\text{My}_{\text{celium}}\text{Tent}$

The biodegradable tent

Team 31
Althaus Simon
Berner Nic
Frongillo Matteo
McCarthy Benjamin
Nyamdorj Narandavaa

Horw, 14th October 2024

Contents

1 Introduction

The growing concern over environmental sustainability and waste reduction has driven innovation in the outdoor gear industry. Disposable camping tents, particularly those used at large-scale events like music festivals, contribute significantly to waste accumulation. To address this issue, our project focuses on developing a biodegradable tent, named $\text{My}_{\text{celium}}$Tent, which leverages mycelium-based composites as a sustainable alternative to traditional nylon and plastic fabrics. Mycelium, the root structure of fungi, offers unique properties such as biodegradability, fire resistance, and minimal environmental impact. This project aims to create an eco-friendly solution that not only meets safety and durability standards but also contributes to reducing post-event waste, aligning with the global shift toward more sustainable and environmentally conscious products.

2 Theory chapter

2.1 Mycelium

Research by Berner Nic

The development of the MyceliumTent is focused on replacing existing nylon and plastic tent fabrics with a mycelium-based fabric in order to make it biodegradable.

2.1.1 Definition

Mycelium is the underground root network created by a mushroom organism. Fungi nourish themselves by secreting digestive enzymes to break down organic material in their surroundings and absorb it through the cell walls of the hyphae, their root network (Moore, Ahmadjian, & Alexopoulos, 2024). Various types of fungi produce mycelium. For this project, the focus is on a fungus with a high growth rate, suitable for the production of biocomposites. In this case, it is possible to use the oyster mushroom (Nicolcioiu, Popa, & Matei, 2016).

Alexopoulos, C. J., Ahmadjian, V., & Moore, D. (2024). *Fungus*. Encyclopedia Britannica. https://www.britannica.com/science/fungus

Nicolcioiu, M. B., Popa, G., & Matei, F. (2016). *Mushroom Mycelia Cultivation on Different Agricultural Waste Substrates*. Scientific Bulletin. Series F. Biotechnologies, 20, 148–153. https://biotechnologyjournal.usamv.ro/pdf/2016/Art25.pdf

2.1.2 Potential of mycelium

The potential of this material lies in its low carbon footprint, low energy and processing cost, and biodegradability (Alaneme et al., 2023, pp. 234–250). The most common use cases in the industry so far include leather, packaging materials, or composites used for construction. However, challenges remain, such as the lack of standardized treatment methods during material development. This project specifically explores biodegradability, breathability, durability, water, and fire resistance, as needed to construct a tent fabric.

Alaneme, K. K., Anaele, J. U., Oke, T. M., Kareem, S. A., Adediran, M., Ajibuwa, O. A., & Anabaranze, Y. O. (2023). *Exploring the Biodegradability of Mycelium-Based Materials*. Alexandria Engineering Journal, 83, 234–250. https://doi.org/10.1016/j.aej.2023.10.012

2.2 Environment

Research by McCarthy Benjamin

This chapter explores different properties of mycelium bio-composites (MBC). MBCs are “composed of an agricultural residue, a non-living material, colonized by a fungus” (Amziane, Merta, & Page, 2023, p. 740). As of today, the full potential of MBCs has not been found, and different production processes and growth combinations (types of fungi and substrates) continue to be tested and compared.

2.2.1 Mycelium bio-composites

Some important properties for this product are sound absorption, thermal conductivity, and moisture buffering value. These properties vary greatly depending on the substrate-fungus combination. Research on fifty unprocessed MBCs found that the sound absorption coefficient differs from 0.5 to 0.95 depending on the frequency,

indicating they are good sound absorbers (Amziane et al., 2023, S. 749). The thermal conductivity value was found to be between 0.057 – 0.085 $\frac{W}{m \cdot K}$, and the mean moisture buffering value was 1.632 (Amziane et al., 2023, p. 749). However, no clear values of water resistance were found, although it is possible to coat the MBC in biodegradable polyurethanes or beeswax for extra water resistance.

Amziane, S., Merta, I., & Page, J. (Eds.). (2023). *Bio-Based Building Materials: Proceedings of ICBBM 2023* (1st ed.). Springer Cham. https://doi.org/10.1007/978-3-031-33465-8

2.2.2 Mycelium-based leather

One of the MBC products in use today is mycelium-based leather (MBL). Research has shown that the order of polyporales fungi, specifically Fomitella fraxinea, in combination with a substrate made of sawdust and rice bran, is best suited for the production of MBL (Raman, Kim, Kim, Oh, & Shin, 2022). After harvesting, the composites are plasticized (with a biodegradable mixture) and hot-pressed, forming a leather-like material. These processes increase tensile strength, elongation percentage, and reduce water absorption. MBL has a mean tensile strength of 8.49 MPa, can elongate up to 58.86%, and has a water contact angle of up to 129.63°, making it hydrophobic (Raman et al., 2022).

Raman, J., Kim, D.-S., Kim, H.-S., Oh, D.-S., & Shin, H.-J. (2022). *Mycofabrication of Mycelium-Based Leather from Brown-Rot Fungi*. Journal of Fungi, 8(3), 317. https://doi.org/10.3390/jof8030317

2.2.3 Biodegradability

Depending on the fungi and substrate used, the biodegradation duration can vary. For example, using Pleurotus ostreatus on a bamboo-based substrate coated with beeswax for increased water resistance shows a mass reduction of 64.13% after two months (Gan et al., 2022). However, due to insufficient research on the biodegradability of other MBCs, no definitive information can be provided on the biodegradability of class-sharing fungi like polyporales.

Gan, J. K., Soh, E., Saeidi, N., Javadian, A., Hebel, D. E., & Ferrand, H. L. (2022). *Temporal characterization of biocycles of mycelium-bound composites made from bamboo and Pleurotus ostreatus for indoor usage*. Scientific Reports, 12(1), 19362. https://doi.org/10.1038/s41598-022-24070-3

2.3 Structure and Setup

Research by Althaus Simon

There are several construction options available for tents. To determine the most suitable option for our purposes, this section evaluates the advantages and disadvantages of the most common tent designs. Hilleberg, a manufacturer of high-quality expedition tents, prioritizes ease of use, which aligns with the criteria important for our product. Therefore, their approach to tent construction serves as a relevant reference for this analysis. Hilleberg categorizes its tents by label, with the Yellow Label being the most applicable to our needs, as these tents are designed for use during snow-free months and in protected environments, or in warmer climates.

Hilleberg. (2024b). *Our Label System*. https://hilleberg.com/eng/discover/our-label-system

The two most common constructions are Tunnel Tents and Dome Tents. Tunnel tents provide the best space-to-weight ratio, making them ideal for mobile journeys where the tent is frequently set up and taken down. Their lighter overall design is advantageous for users who carry their gear during the day. However, tunnel tents are less stable in windy or snowy conditions and typically require pegging to remain upright.

In contrast, dome tents offer greater stability, particularly in adverse weather conditions such as snow or high winds. They are better suited for base camp setups, where they can remain stationary for extended periods. Some dome tents are freestanding, which eliminates the need for pegging and makes them useful in terrains like rocky or gravelly soil. Despite these advantages, dome tents tend to be heavier and provide less space for the weight they add.

Hilleberg. (2024a). *Choosing the Right Tent*. https://hilleberg.com/eng/discover/choosing-the-right-tent

In addition to tunnel and dome tents, instant tents represent another construction option that has gained popularity in recent years due to improvements in ease of setup. These tents combine features of both tunnel and

dome designs, offering a balance between spaciousness and stability. Instant tents are particularly advantageous for users seeking quick and simple setup, often requiring minimal effort. However, they are generally not designed to withstand harsh environmental conditions such as strong winds or heavy snow, making them more suitable for mild weather and less extreme environments.

Outdoor Life. (2024). *The Best Instant Tents of 2024, Tested and Reviewed.* https://www.outdoorlife.com/gear/best-instant-tents/

2.4 Marketing

Research by Nyamdorj Narandavaa

The analysis of the marketing of camping tents and outdoor equipment is based on the use of strategies leveraged to reach and engage consumers globally, in Europe, and Switzerland. Nowadays, the use of social media is a key focus for product promotion and customer loyalty through targeted advertising and influencers.

2.4.1 Worldwide Market

In 2022, the global camping tent market reached a total value of USD 2.65 billion. The future of this market is positive; in fact, it is set to grow further to USD 4 billion by 2028. This positive outlook is possible due to the increase in outdoor recreation and nature tourism.

Research, E. M. (2023). *Global camping tent market report and forecast 2023–2028.* https://www.marketresearch.com/Expert-Market-Research-v4220/Global-Camping-Tent-Forecast-35387212/

2.4.2 European Market

According to reported projections, by 2029 the European camping tent market will grow significantly, reaching a value of USD 1.50 billion. The analysis covers various product categories, materials, and capacities, highlighting the increasing demand for innovative and practical solutions in line with new camping trends.

Intelligence, A. A.
bibinitperiod. (2024). *Europe camping tents market - industry outlook and forecast 2024–2029.* https://www.arizton.com/market-reports/camping-tent-market-europe

2.4.3 Swiss Market

The analysis of the camping tent market in Switzerland focuses on growth trends driven by increased outdoor activities and investment in sustainable materials. Changes in consumer preferences are also part of the analysis.

6Wresearch. (2023). *Switzerland camping tent market - industry outlook and forecast 2023–2030.* https://www.6wresearch.com/industry-report/switzerland-camping-tent-market

2.4.4 Marketing Strategies

Key marketing strategies for outdoor brands are analyzed based on their impact on their audiences. In fact, content posted on social media is strongly considered, facilitating visibility through influencers, who play a key role in product promotion and customer loyalty.

News, M. M. (2024). *Most important strategies to market your outdoor brand effectively.* https://mitechnews.com/guest-columns/most-important-strategies-to-market-your-outdoor-brand-effectively

2.5 Safety

Research by Frongillo Matteo

In the development of a disposable tent, ensuring safety is paramount, particularly for use in crowded and temporary environments such as music festivals. The incorporation of sustainable materials like mycelium necessitates adherence to safety standards, focusing on both mechanical performance and fire protection. These aspects are crucial to safeguard users, mitigate fire-related risks, and offer an eco-friendly solution that minimizes post-use waste.

2.5.1 Fire resistance of mycelium

Mycelium-based composites offer significant advantages in terms of fire resistance, making them well-suited for mass gatherings where the fire hazard is elevated. Compared to synthetic alternatives, mycelium produces less smoke and fewer toxic emissions when exposed to flames, reducing health risks during emergencies. Additionally, the inclusion of silica-rich substrates, such as rice hulls, enhances its fire-retardant properties, ensuring greater protection in densely populated festival settings.

Jones, M., Bhat, T., Kandare, E., et al. (2018). *Thermal Degradation and Fire Properties of Fungal Mycelium and Mycelium-Biomass Composite Materials.* Scientific Reports, 8, 17583. https://doi.org/10.1038/s41598-018-36032-9

2.5.2 Environmental impact and safety

A major benefit of mycelium in the context of this patent is its minimal environmental footprint, both during use and after disposal. Unlike conventional synthetic materials, mycelium composites release negligible amounts of CO2 when combusted. This is especially important for products designed for temporary outdoor use, as it helps limit air pollution and reduces the risk of toxic exposure during unexpected incidents. Moreover, the biodegradable nature of mycelium resolves the issue of waste accumulation post-festival.

Madusanka, C., Udayanga, D., Nilmini, R., et al. (2024). *A review of recent advances in fungal mycelium based composites.* Discover Materials, 4, 13. https://doi.org/10.1007/s43939-024-00084-8

2.5.3 Mechanical safety properties

Myceliums mechanical strength offers another advantage, particularly in ensuring structural stability under varying environmental conditions typical of festivals. The compressive strength and resilience provided by fungal fibers ensure that the tent remains secure and functional throughout its use, offering both physical protection and fire resistance.

Teeraphantuvat, T., Jatuwong, K., Jinanukul, P., Thamjaree, W., Lumyong, S., & Aiduang, W. (2024). *Improving the Physical and Mechanical Properties of Mycelium-Based Green Composites Using Paper Waste.* Polymers, 16(2). https://doi.org/10.3390/polym16020262

2.5.4 Safety in camping applications

For the patent, it is essential to meet established safety regulations for camping shelters, such as the DIN EN ISO 5912:2020 standard, which governs both mechanical and fire safety requirements. The use of mycelium not only satisfies these standards but also adds the benefit of biodegradability, making it an ideal choice for eco-conscious outdoor events. After its lifecycle, the tent naturally decomposes, significantly reducing environmental impact and festival-generated waste.

DIN Deutsches Institut für Normung e.V. (July, 2020). *DIN EN ISO 5912 Camping tents – Requirements and test methods.* https://www.din.de/en/getting-involved/standards-committees/nasport/publications/wdc-beuth:din21:316989855?destinationLanguage=&sourceLanguage=

3 References

6Wresearch. (2023). *Switzerland camping tent market - industry outlook and forecast 2023–2030*. https://www.6wresearch.com/industry-report/switzerland-camping-tent-market

Alaneme, K. K., Anaele, J. U., Oke, T. M., Kareem, S. A., Adediran, M., Ajibuwa, O. A., & Anabaranze, Y. O. (2023). *Exploring the Biodegradability of Mycelium-Based Materials*. Alexandria Engineering Journal, 83, 234–250. https://doi.org/10.1016/j.aej.2023.10.012

Alexopoulos, C. J., Ahmadjian, V., & Moore, D. (2024). *Fungus*. Encyclopedia Britannica. https://www.britannica.com/science/fungus

Amziane, S., Merta, I., & Page, J. (Eds.). (2023). *Bio-Based Building Materials: Proceedings of ICBBM 2023* (1st ed.). Springer Cham. https://doi.org/10.1007/978-3-031-33465-8

DIN Deutsches Institut für Normung e.V. (July, 2020). *DIN EN ISO 5912 Camping tents – Requirements and test methods*. https://www.din.de/en/getting-involved/standards-committees/nasport/publications/wdc-beuth:din21:316989855?destinationLanguage=&sourceLanguage=

Gan, J. K., Soh, E., Saeidi, N., Javadian, A., Hebel, D. E., & Ferrand, H. L. (2022). *Temporal characterization of biocycles of mycelium-bound composites made from bamboo and Pleurotus ostreatus for indoor usage*. Scientific Reports, 12(1), 19362. https://doi.org/10.1038/s41598-022-24070-3

Hilleberg. (2024a). *Choosing the Right Tent*. https://hilleberg.com/eng/discover/choosing-the-right-tent

Hilleberg. (2024b). *Our Label System*. https://hilleberg.com/eng/discover/our-label-system

Intelligence, A. A.
bibinitperiod. (2024). *Europe camping tents market - industry outlook and forecast 2024–2029*. https://www.arizton.com/market-reports/camping-tent-market-europe

Jones, M., Bhat, T., Kandare, E., et al. (2018). *Thermal Degradation and Fire Properties of Fungal Mycelium and Mycelium-Biomass Composite Materials*. Scientific Reports, 8, 17583. https://doi.org/10.1038/s41598-018-36032-9

Madusanka, C., Udayanga, D., Nilmini, R., et al. (2024). *A review of recent advances in fungal mycelium based composites*. Discover Materials, 4, 13. https://doi.org/10.1007/s43939-024-00084-8

News, M. M. (2024). *Most important strategies to market your outdoor brand effectively*. https://mitechnews.com/guest-columns/most-important-strategies-to-market-your-outdoor-brand-effectively

Nicolcioiu, M. B., Popa, G., & Matei, F. (2016). *Mushroom Mycelia Cultivation on Different Agricultural Waste Substrates*. Scientific Bulletin. Series F. Biotechnologies, 20, 148–153. https://biotechnologyjournal.usamv.ro/pdf/2016/Art25.pdf

Outdoor Life. (2024). *The Best Instant Tents of 2024, Tested and Reviewed*. https://www.outdoorlife.com/gear/best-instant-tents/

Raman, J., Kim, D.-S., Kim, H.-S., Oh, D.-S., & Shin, H.-J. (2022). *Mycofabrication of Mycelium-Based Leather from Brown-Rot Fungi*. Journal of Fungi, 8(3), 317. https://doi.org/10.3390/jof8030317

Research, E. M. (2023). *Global camping tent market report and forecast 2023–2028*. https://www.marketresearch.com/Expert-Market-Research-v4220/Global-Camping-Tent-Forecast-35387212/

Teeraphantuvat, T., Jatuwong, K., Jinanukul, P., Thamjaree, W., Lumyong, S., & Aiduang, W. (2024). *Improving the Physical and Mechanical Properties of Mycelium-Based Green Composites Using Paper Waste*. Polymers, 16(2). https://doi.org/10.3390/polym16020262

4 Declarations

- *DeepL* has been used as a spell-checker;
  https://www.deepl.com/
- *ChatGPT 4o* and *ChatGPT o1-preview* have been used as the APA 7 citation corrector.
  https://chatgpt.com/