Challenges to the adoption of Textile Biomaterials and the potential role of Digital Supply Chain Platforms

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Abstract

The damages of the textiles and apparel industry are well documented. Fibre choice has a significant impact. Biomaterials show strong potential for supporting material flows that sustainably integrate waste (Circular Economy); however, their adoption is challenging for brands and suppliers. This qualitative case study investigated brands' and suppliers' experiences, needs, and wishes for a digital procurement platform. Results found four key issues: honesty and transparency in business, a lack of standards, data burden, and communication challenges currently harm the adoption of biomaterials. If developers of the so-called ‘Industry 4.0’ procurement platforms can provide the information needed for decision-making, minimise the burden of maintaining evolving datasets, and facilitate the exchange of swatches, samples and final orders, digital platforms could positively contribute to adopting biomaterials in the textile industry.

Introduction

The damages of the textiles and apparel industry are well documented, with fibre choice having a significant impact. Biomaterials show strong potential for delivering lower production impacts while supporting material flows that sustainably integrate waste flows (Circular Economy). However, their adoption can be challenging for brands and suppliers. This qualitative case study investigated brands' and suppliers' experiences to identify the challenges in adoption of biomaterials, focusing on the needs and wishes that could inform a digital platform. The study considered factors ranging from technology to honesty and transparency, standards, data, and communication.

Literature Review

Biomaterials show potential for the Circular Economy (Ribul et al., 2021) as they derive from a natural origin, are durable, and naturally decompose. (Costa et al., 2020; Dissanayake and Weerasinghe, 2021). Biomaterials can also be produced from renewable resources and replace traditional petroleum-based textiles in existing processes (Glew et al. 2012; Egan and Salmon 2021). Yet biomaterials suffer from slow adoption, with multiple studies offering rationale for this. Biomaterial viability is currently difficult to evaluate due to the need for comparable testing standards and sample availability. In addition, independent research assessment of impact at scale and performance is

lacking (Thakker and Sun 2020) as many suppliers fail to report the impact of biomaterials (Torres et al. 2020).

Rognoli et al. (2022) highlight the industry's strong focus on requiring biomaterials to directly match the properties of existing materials. Glew et al. (2012) also discuss concerns about competition with food crops. Most biomaterials are in early Technology Readiness Levels (TRLs), with unanswered questions around cost, scalability, sustainability, and performance (Ghosh et al., 2023; D'Itria et al., 2021). In addition, regulations have favoured fossil-based materials (Ladu et al. 2019). Table 1 below summaries some of the issues with biomaterials highlighted in the literature.

Topic	Source(s)
Technology readiness	(Roos et al. 2019)
Cost	(Morrow et al. 2023; Ghosh et al. 2023)
Scalability	(Morrow et al. 2023; D'Itria et al. 2021)
Performance issues	(Rajesh 2023; Ghosh et al. 2023)
Lack of consistent terminology	(Fletcher et al. 2021)
Regulatory challenges	(Rajesh 2023; Ladu et al. 2019)
Research and development funding challenges	(Charnley et al. 2024)
Sustainability scepticism	(Egan and Salmon 2021)
Consumer perceptions	(Petreca et al. 2022; Fletcher et al. 2021)
Competition with food crops	(Glew et al. 2012)

Table 1. Identified gaps or challenges with biomaterials

Many authors promote the use of procurement platforms as a solution, hence the focus on so-called ‘Industry 4.0’ procurement platforms as key stakeholders for this research, as they hold the potential to provide the information needed to increase the adoption of biomaterials.

Methodology

This qualitative study utilises design research methods to seek novel perspectives on suppliers' and brands' experiences with biomaterials and the platforms they use. This approach explicitly charts a path from practical problems to desired futures (Peffers et al., 2007). Design research aids strategy with deep, communicable, user-centred insights that empower innovation in nascent environments (Holtzblatt and Holtzblatt 2014). Methodological limitations lie in reduced generalizability and bias from the small sample size (Collins et al. 2004).

Methodology Overview

A qualitative approach composed of semi-structured interviews was chosen. The quality of the findings was validated via an interview with a procurement consultant. Semi-structured interviews were used to gather participants’ internal perspectives via open-ended conversations (Wengraf, 2001).

Participants & Sourcing

Twelve (12) participants were invited. Eight (8) responded. A recommended minimum of five participants was reached, with six (6) professionals joining (Nielsen and Landauer, 1993). Participants were sourced by ‘cold outreach’ and snowball sampling to minimise bias. Ethical approval was granted by the ethics board at the Royal College of Art (RCA) and all participants completed consent forms before participating in the study.

The following groups were represented: One (1) Material Supplier, one (1) Procurement Consultant, one (1) Freelance designer working with large performance brands, and three (3) represented Apparel Brands's perspectives. Participants represented senior roles at major brands and established start-ups across footwear, outdoor and performance, luxury accessories, and women's boutique apparel sectors.

Thematic analysis

Computer-aided thematic analysis helped manage the large amounts of qualitative data (Wengraf, 2001, page 28), coding emergent themes on an ongoing basis (Behar-Horenstein, 2018). Theoretical constructs were refined with each interview to corroborate their potential strength (Eisenhardt, 1989). This study does not attempt to construct Grounded Theory due to the limited sample, interdisciplinarity, and geographical scope (Behar-Horenstein, 2018).

Results and Discussion

Business Motivations

Table 2 summarises the key motivations highlighted by participants for adopting biomaterials.

+	Pushing circularity forward (traceability, biomaterial awareness, reducing petroleum-based materials)
+	Positively driving an industry shift
+	Maintaining competitiveness
+	Legislative and Compliance pressure
+	Financial promise and opportunity
+	Reducing petroleum-based material use
+	Reducing animal cruelty
+	Continuing heritage
+	De-globalizing and re-localising

Table 2. Business motivations for participating in the sustainability agenda

Pain points and blockers

Participants highlighted the following key pain points in procuring and using biomaterials and how that introduces friction, making action difficult and making the use of biomaterials less likely.

a. Misalignment of expectations around biomaterials and their commercial readiness: The most common pain is around expectations and commercial readiness; Some brands "won't talk about a product unless [they] have a final test result on a finished product showing us what is in [it]" (Brand participant 1). Participants expect biomaterials to perform equally to traditional materials they are replacing. Currently, these expectations are often not met.

b. Clarity and honesty about material composition and performance: "When it comes to plastics, it's tough to trace the bio content as chemically it's the same" (Brand Participant 1). Suppliers know that "there's no way of testing the [actual] content" (Brand Participant 2), which opens opportunities for misbehaviour mentioned by several participants. This is also exacerbated by a sentiment that they cannot trust certifications. Some participants shared stories of purchasing "sustainable materials" with a promise of certain percentage of "bio-content" or "recycled content", only later finding that to not be true. Another common comment related to colour fastness and abrasion resistance of alternative (biomaterial) leathers, where the materials did not match promised performance. Some

participants commented that some suppliers misrepresent such parameters or engage in optimistic thinking and overpromising. On the other hand, the interview with a biomaterial supplier shared a pain of having to “debunk myths and overly optimistic expectations”. This suggests that the industry would benefit from systems and a philosophy that encourages greater transparency between the parties.

c. Difficulties managing communication (both ways) and finding shared language: All participants mentioned challenges with timely, transparent communication and shared language. Brand participant 2 mentioned that “[redacted] was so overwhelmed by demand it took them almost a year to send us a sample”. Communication is clearly a challenge as the number of inquiries both ways is said to be “difficult to manage”. Getting timely responses seems to be difficult, as one participant put it, they “waited almost two years to get samples”. Another common pain is finding a “shared vocabulary” as involved parties are either technical, creative, or business in background. It would be beneficial to find ways to facilitate structured and honest conversations between the parties, preferably away from their email.

d. Burden of maintaining information on biomaterials: Current practice seems to be that of manual upkeep of spreadsheets containing all information on used materials. This has proven difficult to keep up to date as biomaterials, and their properties, are constantly changing. Participants highlighted that it would be useful to have a platform that can reduce this burden of ‘double-recording’ by providing a single source of truth about materials.

Participants highlighted the following blockers that can prevent action.

a. Lack of biomaterial availability, price, and commercial readiness: The first and most cited blocker was the readiness of biomaterials. That is biomaterials’ readiness to fulfil expectations of commercial textiles production. Whether that be performance or manufacturing integration. Second is availability. Good quality biomaterials are difficult to discover and order. It appears that a number of innovators are creating biomaterials but are at an early stage of development. Third is price. “Sustainable materials tend to be more expensive for various reasons” - cost, low production volumes, or raw material input (Freelance participant), their availability is limited, and “they're not available [locally]” driving high import costs (Brand participant 3). A biomaterials platform needs to increase openness regarding availability and readiness, which in turn could lead to the establishment of research and development relationships that could help small suppliers mature their stock, and brands participate in systemically meaningful use of smaller product runs.

b. Lack of performance compared to currently used materials: being the biomaterial lack of performance; or conversely the brands’ expectations that biomaterials will perform equally to traditional materials. This was highlighted as being particularly problematic in footwear and performance-wear: “products were cracking after a short while in consumer’s hands” (Brand participant 2).

c. Low production volumes, challenges with minimum order quantities (both high or low): Production volumes and ‘Minimum Order Quantities’ pose a double-edged issue. Working with “a big brand, then they need quite a lot” (Freelance participant), this may be challenging to supply. However, smaller orders manufactured for emergent sustainable brands are often not profitable for Suppliers. For example, brand participant 1 highlighted that they manufacture “1,5 million shoes”, which requires large amounts of consistently performing leather. Conversely, from an “Early” Supplier’s perspective, it would be useful to find brands who are looking for smaller production runs and are open to using such materials experimentally.

d. Trade secrets and exclusivity agreements limiting the availability of the most promising materials: Another commonly cited blocker is around trade secrets, non-disclosure practices, and exclusivity. Brand participant 1 cited that they could not adopt a biomaterial because “Adidas or Nike snatches them first.” The interviewed supplier specifically cited that they “obviously did not sign an exclusivity agreement,” with their partner to keep their development open. Likewise, they said that they wish for “sharing practices,” and emphasized challenges with having to “reverse engineer” competitors’ methods to learn. There is therefore an apparent need to encourage industry openness and collaboration, to accelerate the transition towards a more sustainable textiles industry. The findings also

suggest that exclusivity agreements hinder industry progress and are frustrating for both brands and suppliers.

Overall, biomaterials are receiving a mixed reception due to several challenges—many related to process difficulties not connected to their technology readiness. A new biomaterials management platform can potentially address emergent needs. However, there is a critical misalignment of expectations about biomaterials' performance and availability. Brands and designers seem to see novel materials as a 1-to-1 replacement for current stock (i.e., matching the performance of animal leather). Partly, suppliers' hope to secure contracts may overpromise on such hopes. There were accounts given of actors who actively misrepresented bio-material composition or performance (e.g., false promises on colour fastness or disclosed bio/recycled content).

Challenges in communication, standardization and consistency prevent effective collaboration. Maintaining non-standard repositories of constantly evolving information is challenging. Operations are currently managed across several unsuitable platforms (e.g., WhatsApp). Further, a lack of tactile presentation and experiences limits designers' ability to envision biomaterial-based products, which is essential considering their qualitative differences. Trade secrets and exclusivity agreements are also frustrating for both sides—again limiting broad adoption.

Some brands think suppliers will not share material information, but the interviewed supplier did so readily and advocated for industry transparency, motivated by the desire to disrupt harmful industrial practices. Wishful thinking and myths about biomaterials also contribute (i.e., the readiness of biomaterial composting infrastructure). The industry must increase transparency to create realistic expectations of novel biomaterials and reduce frustration on both sides of the exchange.

Biomaterial procurement platforms are uniquely positioned to encourage transparency. They enforce structured benchmarks of "what sustainability looks like" and even address issues like multilateral procurement to aid with minimum order-quantity challenges.

Conclusions and Future Research

The study suggests that developers of biomaterials platforms should focus on facilitating an honest and open exchange of all data needed for decision-making, minimising the burden of keeping data up to date, and enabling the exchange of swatches, samples, and final orders. The somewhat adversarial relationship between biomaterial suppliers and clothing brands must evolve into one based on collaboration and sharing. Suppliers will benefit from cost-effective testing grounds to aid development, and brands will gain much-needed storytelling of their contribution to sustainability. They will also have a stake in developing materials to fit performance requirements.

As this qualitative study utilized a limited sample of participants, further research is needed to validate the generalizability of our findings.

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