

technology by universities. Residual use promotes the circular economy while stimulating new ways of generating income for those who make up the agribusiness chain. Regarding communication, *mush.eco* took less than 12 hours to answer this survey, which highlights the attention given to social networks, however not all questions were answered. In terms of understanding, Instagram has become effective in complementing the information on the institutional page, favoring a good understanding of the project and the process through the highlights, audiovisual and subtitles, exposing the reader to a holistic view about sustainability and the potential of biomaterials. Despite having fewer followers, Facebook is constantly updated and is also effective in understanding the proposal (See Figure 6).



Figure 6. Compilation of images showing composition, process and some applications of the *Mush.eco* material. Source: (<https://www.instagram.com/mush.eco/>)

Adriano Di Marti - Desserto (México)

In order to create an alternative to animal leather, Adrián López Velarde and Marte Cázares developed a vegan leather made with *Notus cacti*, a species abundant in Mexico. The leather, called *Desserto Pele*, is a mixture of cactus and cotton and has different thicknesses, colors and textures, it is breathable and partially biodegradable. According to the creators of the company Adriano Di Marti, manufacturer of the material, it appeared with the aim of reducing the impact and environmental pollution, that is, to be a sustainable alternative and free from animal cruelty, without toxic chemicals, phthalates (an additive that makes plastic more malleable) and PVC. After two years of research, they launched vegan material in July 2019 with competitive characteristics compared to animal or synthetic leather, such as elasticity, personalization and breathability. Soft and pleasant to the touch,

high resistance and durability, with at least 10 years, the organic and sustainable product promises to be a good alternative to replace the use of animal leather and other synthetic materials that are not ecologically correct, as it has certification and quality enough to be used in making clothes, accessories, furniture and even car interiors. It recently won the VII International Green Product Award, an award that recognizes the best innovative and sustainable products and services made by companies and startups worldwide.

The company is present in several social networks, Instagram is its platform with the largest number of followers, with 67 thousand. On Instagram and Facebook it was possible to find and perceive information more quickly through images, texts and short videos. A criticism would be the lack of highlights on Instagram with faster information on the composition of the material, manufacturing and products, as it would facilitate the organization and even faster apprehension of this information. Although on the website, it is possible to absorb this and other information about this project. Some questions were sent on the company's profile on Instagram, but there was no feedback on this channel, which is currently the most direct means of communication with customers (See Figure 7).



Figure 7. Compilation of images showing composition, process and some applications of the Desserto material. Source: (Prepared by the authors of <https://www.instagram.com/desserto.pelle/>)

Soubio (Brazil)

It is a disposable packaging company that emerged in 2019 at the initiative of the entrepreneur Fabiana Arruda Gonçalves. Its products are alternatives to the conventional disposable, as they are biodegradable and compostable, that is, they undergo faster decomposition through natural microorganisms (bacteria) in which the decomposed material gives rise to an organic liquid that serves as fertilizer for plants, thus causing less impact on the

environment. For this reason, although more expensive than other alternatives, even so, they are increasingly being recognized as an excellent solution for packaging. According to an interview with Martins (2020) on the Rede Food Service website in December 2020, Fabiana Arruda informs that 20% of all the garbage produced in Brazil is made up of plastic packaging that takes time to decompose, thus, its biodegradable products would be a good option solution to this problem of an increasing production of waste that pollutes and causes various damages to animals and the environment. The products are imported from Asia, but she confirms that she personally developed the entire line with partners. It highlights that every product has the company's DNA, whose tripod is in quality, practicality and sustainability. On the institutional website, products with 4 types of biodegradable and affordable materials are available for sale: wood, kraft paper, corn starch and sugarcane bagasse. The latter is the company's most relevant type of packaging and degrades from 3 to 6 months in the environment. There are several product options with these materials such as: cutlery, plates, glasses, straws, bowls, pots, trays and packaging. Soubio is present in several social networks, Instagram has about 3 thousand followers and Facebook only 301, a number considered low due to the relevance of the theme. On Instagram, highlights are organized for products and certifications, among others, which facilitate the perception of information in a faster and more specific way, but there is no information about the composition of materials and the manufacturing process, not even on the website, which only focuses on selling products. The contact with this company was not successful, the questions sent in the Instagram profile and by e-mail were not answered, only the whatsapp channel answered and only about the degradation time of the sugarcane bagasse material, and sent the catalog selling the products (See Figure 8).

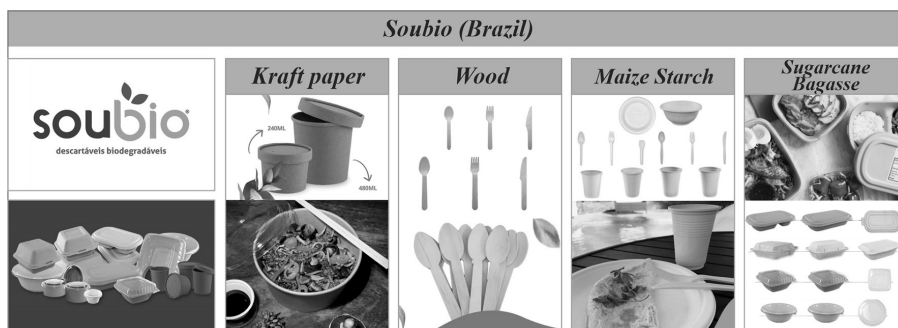


Figure 8. Compilation of images showing the products by type of material sold by Soubio. Source: (Prepared by the authors of <https://www.instagram.com/soubioBrasil/>)

Beyond Leather (Denmark)

The creator of the business is the entrepreneur Hannah Michaud, who together with Mikael Eydt are at the head of the company Beyond Leather, founded in 2017. The material developed is a vegan “leather” from residues from the production of apple and cider juice. It is 100% biodegradable and can be rigid or highly flexible, and according to the website, it can even be eaten, as its ingredients are sustainable and non-toxic. It is made up of at least 50% of the natural product of the apple, more precisely the leftover from manufacturers after squeezing the apples, and the other 50% consists of ingredients of sustainable origin. Its coating is a mixture of bio-based ingredients and derivatives of fossil fuels. It was created with the intention of being a real alternative to animal leather so that the difference between them is not noticed. This is because there are several problems of unsustainability in the process of manufacturing animal leather, such as, for example, the creation of cattle that leads to deforestation, the excessive use of water, land, gas emissions that contribute to climate change and the traditional pigmentation of animal leather using chromium and other toxic chemicals. For this reason, the Danish startup recently won, among 15 other competitors, the Clim@ 2020 competition, an event that rewards startups that demonstrate climate impact.

According to the company, the process for manufacturing vegan leather takes 5 steps and can be completed in 1 day. It uses only five kilos of apple pulp to make one square meter of its leather, working with the concept of Upcycling that gives new life to materials that would be discarded creating a product with greater added value than the original. Sustainable vegan fashion is on the rise and it is clear that there is demand and market for this product, as demonstrated by the American companies Tommy Hilfiger and the French brand Caval, which launched shoes in 2020 with vegan leather. This waste-based leather alternative has great potential and gives the fashion industry a real sustainable option for replacing animal and synthetic leather. The company received new investments and its production plant in Denmark has been increased. In this sense, the company’s philosophy is also responsible production, since the country is already known for its green energy and fair working conditions, including the choice of apple was to take advantage of the various apple and cider juice producers in the country, since the company informs that the same process can be implemented with all types of fruits.

It is present on Instagram with some images of the ready-made and pigmented material, has few followers, approximately 5,000, but there is no organization of the highlights to facilitate a better understanding of the manufacture of the material. On Facebook, there are about 800 followers. Here there is more information about the process and short videos showing some details of the pressing of the apples to obtain the material input, but there is also little information about the composition of the material itself, and it is not informed about which natural polymers are added. The institutional website is even less informative, which meant that there was a need to investigate from other sources, such as magazine sites for more information. The questions that were sent in the Instagram profile and by e-mail were not answered until the conclusion of the article (*See Figure 9*).



Figure 9. Compilation of images showing Beyond Leather's vegan leather biomaterial made from the residue of apple processing to produce juice and ciders, details of the manufacturing process and some of its possible applications. Source: (Facebook: Elaborated by the authors of <https://www.facebook.com/BeyondLeatherMaterials>).

Mediated Matter Group - MIT Media Lab/ Neri Oxman (USA)

This last case is different, as it is a research group, the Mediated Matter Group - MIT Media Lab, headed by architect and disruptive designer Neri Oxman. The group focuses on nature-inspired design, with research at the intersection of computational design, digital fabrication, materials science and synthetic biology. They create biologically inspired design manufacturing tools and technological structures in order to improve the relationship between natural and artificial environments. There is specific research on Material Ecology that considers computing, manufacturing and the material itself to be synergistic in order to establish new forms of design and new processes of material practice at the intersection of computer science, materials engineering, design and ecology. In this approach, products and buildings are designed as living interactive entities: environmentally informed, computationally grown, digitally manufactured and biologically enhanced.

Some examples that illustrate this new way of thinking about the material being built with the living organism itself are the Silk Pavilion I and II and the Synthetic Apiary, which explores the combination of digital fabrication and biological fabrication in Design and Architecture. In the case of Silk Pavilion I, they used the silkworms' ability to create a 3D cocoon made of a single silk thread to create a wet pavilion, built artificially, partly by the

silkworms themselves. The artificial part was made using an algorithm that has a single and continuous thread through patterns that provide varying degrees of density, and the natural part was achieved by adding the silkworm itself in the Pavilion to vary the overall density end, as if a biological “printer” was implanted in the remodeling of the structure. A set of 6500 silkworms was placed in the lower frame of the rotating dome, consisting of 26 panels. Thus, these animals reinforced locally the spaces between the silk fibers that were arranged by the CNC machine. The innovation of the project is precisely in the use of the CNC machine that simulates the construction pattern of silk as a base and uses the silkworms themselves to densify the most empty areas of this same Pavilion, remodeling the initial model.

Thus, at Silk Pavilion II, they study biologically augmented digital fabrication with silkworms and at Synthetic Apiary, insect communities that live in society and exhibit collective behavior known as “swarming”, prioritizing the group over individual survival, working to achieve common goals. It has been seen that these insects leverage collaborative behavior for construction on a relatively large scale. For example, ants create extremely complex networks through tunnels, wasps generate intricate paper nests with materials from local areas, and bees deposit wax to build intricate beehive structures as seen in some images in *Figure 10*.

The avant-garde degree in the projects of this laboratory is perceived, because combining the creation of new technologies for digital manufacturing with speculative design, they rethink the future of designs that interface with the body, construction and the environment in the bio-digital era.

When it comes to research on social networks, the Mediated Matter Group - MIT Media Lab does not have Facebook or Instagram, but there is an institutional website with a lot of information about the projects, staff and the institution itself. This research considered this platform to be the most complete of all cases, as the information is very well organized and easily understood by automatic and interactive videos, short texts and links to publications with more in-depth information. On Neri Oxman’s Instagram, there are few publications and information about the projects, but there is high visibility, almost 80 thousand followers, and on Facebook, almost 14 thousand followers, however, their website follows the same pattern as the Mediated Matter Group, that is, is very efficient, as there is more specific information, images and explanatory videos in which it was possible to understand very well the projects developed. Contact via Neri Oxman’s Instagram did not receive a response until the article was completed.

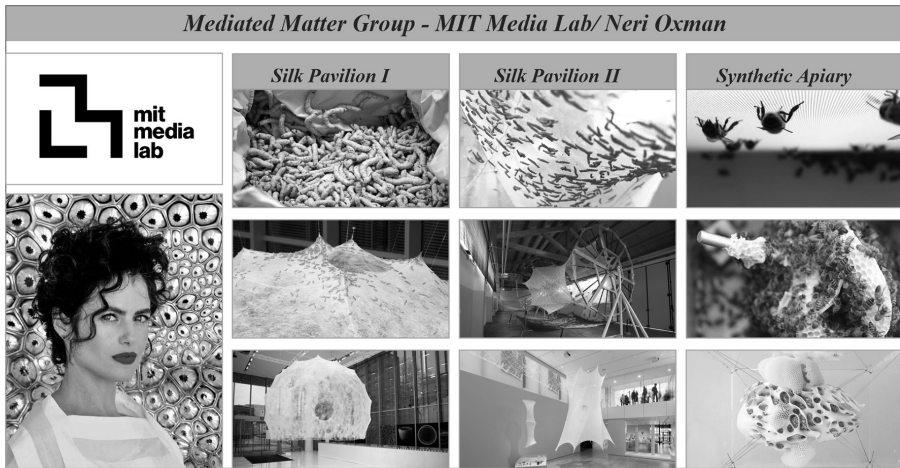


Figure 10. Compilation of images from the Silk pavilion I and II and Synthetic Apiary projects from Mediate Matter Group - MIT Media lab / Neri Oxman. Source: (<https://mediatedmattergroup.com>; <https://oxman.com/>)

Conclusion

It is noticed that it is not always an advantage for the biodegradable to have such a rapid decomposition. In the case of packaging, as in the case of Soubio, it really is something very valid, because as soon as the product is consumed, the packaging is thrown away, so the life of this product is very short. Still, there is a need for some durability as consumer companies need a reasonable amount of time so that packaging does not degrade before they even leave stock. Products such as bags and shoes, as in the example of Adriano Di Marti, it is not interesting that they have a very short useful life, as consumers want durability in this case, so the company opted for a material that is partially biodegradable and lasts 10 years old. This justifies that depending on the situation there is a need for this type of material to have a shorter service life, and other times, a longer one.

So, the first step towards sustainability is to choose the right raw materials, the next is to process them in a way that is not harmful to the environment, and all cases were responsible for these choices. Although it is still more expensive, people are adhering to biomaterials due to environmental awareness.

From the analysis, it was possible to verify that most of the biomaterials developed were biodegradable, and some of them, compostable, which is directly related to the imitation of a principle of nature, whose constructions are likewise sustainable. But not only that, it was observed that each case was solving other relevant issues in terms of sustainability, such as Soubio, whose solution solves a problem of great environmental impact, which is

the issue of garbage, since packaging is its predominant composition, pollute and harm fauna and flora for hundreds of years. Many of the cases proposed a destination for industrial waste, as in the case of Beyond Leather, which uses leftovers from the apple and cider juice manufacturing process; Mush.eco, which reuses agricultural waste to feed the fungal mycelium manufacturing process; Shell Homage, which uses waste from the food industry to manufacture egg and nut shells; and the last, HighSociety, which uses the residue from the wine and tobacco industry to manufacture its composite material. In this case we can also highlight the issue of social activism promoted by the sale of the Senília lamp for the benefit of drug addicts. Finally, in the Adriano Di Marti - Desserto case, its solution presents a compatible and quality material to replace animal leather, since there are serious sustainability problems in traditional leather production. Another important issue is the performance of companies that promote the development of the local community using materials and labor from the region in which they operate, such as BeyondLeather, High-Society and Mush.eco.

Regarding the presence of institutions on social networks, it was possible to see that through Facebook and Instagram the perception and visualization of these biomaterials was faster and easier to access. Instagram's artificial intelligence was valid to suggest several profiles that had to do with the research, but for a deeper analysis it is necessary to search for information on other sites and / or articles related to the case, mainly in relation to the process of manufacturing biomaterials. One hypothesis for this difficulty is that companies do not detail because of industrial secrecy and to avoid competition. Another aspect of the interaction on Instagram refers to the contact through the chat messages in which the survey questions were sent. It was initially imagined that because it is a channel with a quicker response, it would be successful in this communication. However, the contact was not efficient, as many of the profiles asked for questions to be sent by email, and even after sending, they did not return, with the exception of mush.eco, which had a quick but incomplete response.

A different approach, but which is already a reality for the development of biomaterials, is the use of the cultivation of biological organisms for their production, as in the case of Mush.eco, which uses fungi in its composition.

Moving to a new perspective in biomaterials, in the case of the Mediated Matter Group of Neri Oxman, through the silk Pavillion and the bee pavilion, a hybridization of processes is used, in which human intervention is used together with the performance of the animal itself for construction. This brings a disruptive and promising path in this scenario of developing new materials, stimulating further research in this field. Therefore, the vision of a sustainable future, in terms of materials, involves the circular economy approach to production, using industrial waste streams and with the possibility of building with the organism itself.

References

- Arnal, I. P.; Sauer, B.; Navarro, J. G. & Leftery, C. (2008). *Eco productos, en la arquitectura e el diseño*. Barcelona, Catalunya: Ed Ignasi Perez Arnal.
- Benyus, J. M. (1997). *Biomimética: Inovação inspirada pela natureza*. 6ª ed. São Paulo: Ed. Pensamento- Cultrix.
- Circular Economy 100. (2017) Uma economia circular no Brasil: uma abordagem exploratória inicial. Rio de Janeiro: Ellen MacArthur Foundation. Disponível em: https://www.ellenmacarthurfoundation.org/assets/downloads/languages/Uma-Economia-Circular-no-Brasil_Uma-Exploracao-Inicial.pdf. Acesso em: 20 mar. 2020.
- FUNDAÇÃO ELLEN MACARTHUR. What is the Circular Economy. disponível em: <<https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy>>
- Lima, M. A. M. (2006). *Introdução aos materiais e processos para designers*. Rio de Janeiro: Ciência moderna.
- Manzini, E. & Vezzoli, C. (2011). *O desenvolvimento de Produtos Sustentáveis: os requisitos ambientais dos produtos industriais*. 1 ed. São Paulo: Editora da Universidade de São Paulo. 366 p. ISBN 978-85-314-0731-4.
- Manzini, E. & Vezzoli, C. (2002). *O desenvolvimento de produtos sustentáveis: os requisitos ambientais dos produtos industriais*. São Paulo: Edusp.
- Santos, C. (2010). O desenho como processo de aplicação da biomimética na arquitetura e no design. *Revista TÓPOS*. V. 4, Nº 2, p. 144 - 192. Universidade Estadual Paulista, Presidente Prudente.
- Soares, T. (2016). A Biomimética e a Geodésica de Buckminster Fuller: Uma Estratégia de Biodesign. 286f. Dissertação (Mestrado em Design) - Universidade Federal de Pernambuco, Recife, Departamento de Design do Centro de Artes de Comunicação.
- Smol, Marzena; KULCZYCKA, Joanna; AVDIUSHCHENKO, Anna. (2017). Circular economy indicators in relation to eco-innovation in European regions. *Clean Techn Environ Policy*, v. 19, p. 669-678. DOI: <https://doi.org/10.1007/s10098-016-1323-8>
- Thompson, R. (2015). *Materiais Sustentáveis, Processos e Produção*. São Paulo: Editora SENAC. ISBN: 9788539608423.
- Vegconomist. (2021). High Society: “A Reference for Experimental and Sustainable Craftsmanship”. <<https://vegconomist.com/interviews/high-society-a-reference-for-experimental-and-sustainable-craftsmanship/>>

Shell Homage

Instagram: <https://www.instagram.com/shellhomage/>

Facebook: <https://www.facebook.com/shellhomage>

Website: <http://shellhomage.com/>

<https://english.ahram.org.eg/NewsContent/7/47/408150/Life--Style/Style/INTERVIEW-Egyptian-designer-Rania-Elkalla-finds-he.aspx>

Miyuca

Instagram: <https://www.instagram.com/miyucadesignstudio/>

Facebook: <https://www.facebook.com/miyucadesignstudio/>

Website: <https://www.miyuca.it/>
email: info@miyuca.it

HighSociety

Instagram: <https://www.instagram.com/highsocietystudio/>
Facebook: <https://www.facebook.com/highsocietystudio/>
Website: <https://high-society.it/highlight>
PRESS@HIGHSOCIETYSTUDIO.COM
INFO@HIGHSOCIETYSTUDIO.COM

Mush.eco

Instagram: <https://www.instagram.com/mush.eco/>
Facebook: https://www.facebook.com/EmpresaMush/?ref=page_internal
Website: <https://mush.eco/>

Desserto

Instagram: <https://www.instagram.com/desserto.pelle/>
Facebook: <https://www.facebook.com/desserto.pelle>
Twitter: https://twitter.com/desserto_pelle
Pinterest: https://br.pinterest.com/desserto_pelle/_created/
Website: www.desserto.com.mx

Soubio

Instagram: <https://www.instagram.com/soubiobrasil/>
Facebook: <https://www.facebook.com/soubiobrasil.com.br/>
Blog: <https://blog.soubiobrasil.com.br/>
Website: <https://www.soubiobrasil.com.br/>

Beyond Leather

Instagram: <https://www.instagram.com/beyond.leather/>
Facebook: <https://www.facebook.com/BeyondLeatherMaterials>
Website: <https://www.beyondleather.dk/>

Mediated Matter Group - MIT Media Lab/ Neri Oxman

Mediated Matter Group's website: <https://mediatedmattergroup.com>
Neri Oxman's Instagram: <https://www.instagram.com/oxmanofficial/>
Neri Oxman's Facebook: <https://www.facebook.com/NeriOxmanArt/>
Neri Oxman's website: <https://oxman.com/>

Resumen: Recientemente, han surgido muchas empresas y laboratorios académicos que formulan nuevos materiales de origen biológico para su uso en artefactos, en respuesta a

un escenario de insostenibilidad. Este trabajo tuvo como objetivo investigar las instituciones que desarrollaron biomateriales, enfocándose en aquellas que tenían aplicaciones reales. En este sentido, a través de las redes sociales, se encontraron y analizaron varios ejemplos representativos del tema desde una perspectiva cualitativa. Además de un análisis de los datos recopilados a través de imágenes y textos publicados en estas plataformas, también fue posible mapear otros datos como el origen geográfico, el alcance y el compromiso de las instituciones analizadas. Los resultados indican que la inteligencia artificial de Instagram fue válida para sugerir diferentes perfiles que tenían que ver con la investigación, tales plataformas virtuales facilitan la percepción y visualización más rápida de estos biomateriales, sin embargo para un análisis más profundo no fue tan eficiente, aunque sirven para difundir y estimular nuevas iniciativas en este contexto.

Palabras clave: Diseño - Biomimética - Biomateriales - Sostenibilidad - Economía circular - Plataformas digitales

Resumo: Recentemente, muitas empresas e laboratórios acadêmicos surgiram formulando novos materiais de origem biológica para uso em artefatos, em resposta a um cenário de insustentabilidade. Este trabalho teve como objetivo investigar instituições que desenvolveram biomateriais, enfocando aquelas que tinham aplicações reais. Nesse sentido, por meio das redes sociais, diversos exemplos representativos da temática foram encontrados e analisados numa perspectiva qualitativa. Além da análise dos dados coletados por meio de imagens e textos publicados nessas plataformas, também foi possível mapear outros dados como origem geográfica, alcance e engajamento das instituições analisadas. Os resultados indicam que a inteligência artificial do Instagram foi válida para sugerir diferentes perfis que tinham a ver com a pesquisa, tais plataformas virtuais facilitam a percepção e visualização mais rápida desses biomateriais, porém para uma análise mais aprofundada não foi tão eficiente, embora sirvam para divulgar e estimular novas iniciativas neste contexto.

Palavras chave: Design - Biomimética - Biomateriais - Sustentabilidade - Economia Circular - Plataformas Digitais
