

The Green Makeover: Biotechnology 2.0 for Sustainable Fashion & Beauty in the Philippines

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Abstract: Biotechnology 2.0 has been instrumental in transforming the Philippines' fashion and cosmetics industries by offering sustainable and ethical alternatives. This review explores the biotechnological integration in advancing sustainable materials and formulations within Philippine fashion and cosmetics, the challenges and prospects. Notable innovations include Bakong-based fiber extraction, Piñatex (pineapple leaf fiber), and Bananatex (banana fiber fabric)—biocomposites offering biodegradable, high-strength alternatives to synthetics. Further, digital weaving and microbial dyeing processes have helped to reduce the environmental loads. In cosmetics, local brand Pure Culture is the trailblazer of biotech-inspired skincare by opting out of unsustainable variants. The use of AI is making this sector adopt more sustainable practices by eliminating trial-and-error in product selection through personalized, data-driven models while enabling virtual try-ons and customized skincare recommendations based on user input, optimizing product use and reducing waste. Despite these innovations, challenges remain with limited biomanufacturing infrastructure, regulatory hurdles, and high production costs. This study highlights the tremendous potential of the biotechnology-based fashion and cosmetic sector in the Philippines and recommends targeted investment in biofabrication facilities and harmonized regulatory frameworks to position the Philippines as a leader in sustainable and ethical product innovation.

Key Words: Biotechnology; Sustainability; Filipino Fashion & Cosmetics

1. INTRODUCTION

Biotechnology is transforming the worlds of fashion and cosmetics. Genetic engineering and synthetic biology now create sustainable bioengineered fabrics, lab-grown leather, microbial dyes, and biotech-derived cosmetic ingredients, decreasing the dependence on resource-intensive conventional textiles and harmful chemicals (Fernández, 2020; Brunel, 2019).

Within ASEAN, the Philippines is projected to trend upwards despite currently placing fifth in the apparel sector (Figure 1) Such potential shows promising opportunities for investment and expansion (Statista Market Insights, 2024).

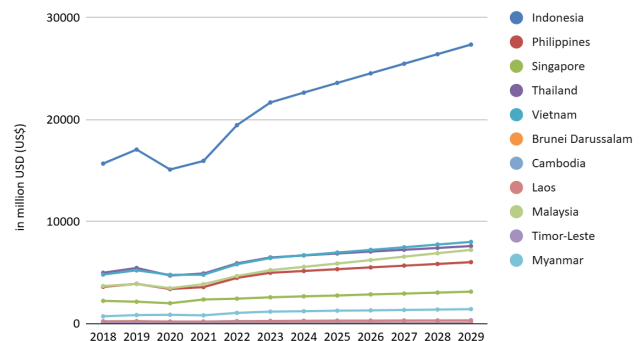


Figure 1. Revenue in apparel across SEA countries (Adapted from Statista Market Insights, 2024)

In personal care, the Philippines has grown steadily (Figure 2) driven by greater consumer demand and expansion in digital retail. Despite trailing behind Indonesia and Vietnam, the country still presents itself as a key player in SEA's beauty industry (Statista Market Insights, 2024).

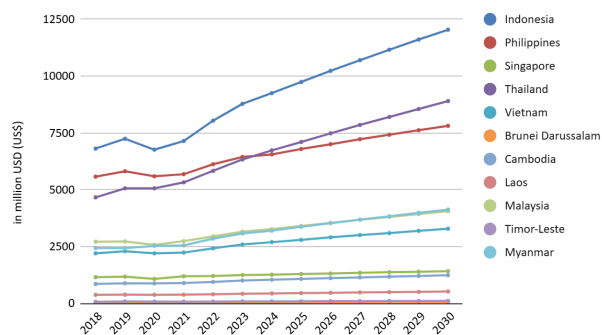


Figure 2. Revenue in beauty and personal care across SEA countries (Adapted from Statista Market Insights, 2024)

Integrating biotechnology in Philippine fashion and cosmetics significantly impacts sustainability, economic growth, and scientific progress. Biofabricated textiles and microbial-based dyes can mitigate pollution, while biotech-derived cosmetic ingredients negate harmful synthetic chemicals. Furthermore, utilizing the country's biodiversity for production can boost economic resilience and meet the growing global demand for sustainable products.

However, its application is challenged by regulatory constraints, economic limitations, and lack of public awareness (Broyd, 2022). Therefore, this review paper aimed to explore the role of biotechnology in the Philippine fashion and cosmetics industries, highlighting key innovations, sustainability initiatives, challenges, and recommendations for research, investment, education, and collaboration.

2. METHODOLOGY

This study utilized a qualitative systematic review, analyzing peer-reviewed journals, government reports, and verified company websites related to

biotechnology in Philippine fashion and cosmetics. Inclusion focused on recent, context-specific literature; outdated and irrelevant sources were excluded. Data were thematically categorized to evaluate current practices and highlight opportunities for advancing sustainability through biotechnology in these sectors.

3. RESULTS AND DISCUSSION

3.1. Biotechnology in the Philippine Fashion

The Philippine textile industry experiences a resurgence as innovation and sustainability are incorporated with biotechnology as microbial textiles, indigenous fibers, and potentials for growth are explored (DOST-PTRI, 2025).

3.1.1. Use of Indigenous and Bio-Based Fibers

The Philippines supplies 85% of the world's demand for flexible and durable abacá fiber (*Musa textilis*) (Araya-Gutiérrez et al., 2022; Philippine Council for Agriculture and Fisheries, 2021). Other indigenous fibers include pineapple (*piña*), banana, coconut, *saluyot*, and *kapok* which utilize waste with minimal chemical inputs (DOST-PRI, 2023; Philippine Textile Research Institute, 2014; Philippine Coconut Authority, 2018). Their extensive applications are seen notably by the government's production of face masks amidst the COVID-19 pandemic using hybrids of the aforementioned fibers (Ochave, 2021).

3.1.2. Textile Processing & Dyeing

Enzyme-engineering textile processing utilizes cellulase and laccase variants to improve thermal stability and dye-degrading capabilities (Singh et al., 2022). The Philippine mangrove (*Avicennia marina*) was proven to have dye-degradation properties, with laccase playing a key role (Obanan et al., 2022). *Escherichia coli* has also resulted in modified strains that produced pigments like β -carotene, indigo, and zeaxanthin (Anshi et al., 2024). These have reformed the fashion industry, allowing less chemical output and biodegradation.

3.1.3 Sustainable & Digital Weaving Technologies

3D printing can reduce waste by minimizing overproduction while remaining compatible with bio-based polymers and plastics (JLC, 2024). Nanotechnology has also allowed for apparel with odor-neutralization, hazard detection, and sweat-free properties (Hedge, 2015). Artificial Intelligence (AI) has also influenced the industry as Filipino designers now incorporate its production and marketing like Guiral's (2023) write-up on the country's first AI fashion shoot. Today, students are learning to harness AI tools to create complex fashion designs (Arasa, 2023), underscoring AI integration in the future.

A notable local effort includes Bakong. Spearheaded by the Design Center of the Philippines, products like Provinciudad and the Spiderlily Collection (as shown in Figure 3) utilize fiber and other indigenous materials (De Borja, 2024).



Figure 3. (a) Provinciudad and (b) Spiderlily Collection (Adapted from DTI Design Center PH, 2023)

Other efforts include Piñatex, a sustainable leather alternative (see Figure 4), which is used by Philippine-based company Ananas Anam in various fashion pieces (Ananas Anam, 2017). Bananatex also uses the abacá-banana plant fiber in creating apparel for foreign brands like Balenciaga (see Figure 4) and Stella McCartney (QWSTION, 2025).



Figure 4. (a) Piñatex and (b) Bananatex in Balenciaga collaboration (Adapted from Ananas Anam, 2017; Species Unite, 2024)

3.2. Philippine Cosmetic Biotechnology

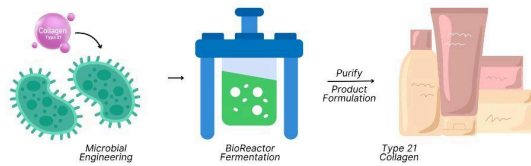
While waiting for a surge in locally crafted biotech products from the upcoming Philippine Cosmetic Garden (Araguas, 2024), a notable local company, Pure Culture, creates sustainable skincare (Gentry, 2023) and has received acclaim at the Organic Beauty Awards (Inocencio, 2024).

3.2.1. Pure Culture's Biotech Ingredients

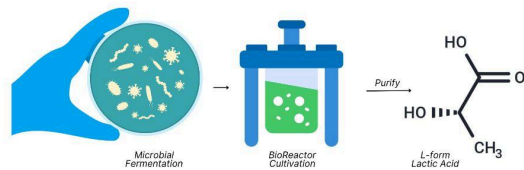
Figure 5 presents the different processes of Pure Culture's biotech ingredients. Gelator's **HumaColl21** outshines traditional bovine variants by offering an alternative to collagen production through microbial fermentation instead of raising cattle to meet demand and subsequently raising methane production. Gelator's **Elastapure** is a synthetic variant of elastin made through the same process (Wills, 2023).

Purac's **Lactic acid** is produced from microbial fermentation using sucrose or glucose (Jem et al., 2009) instead of petroleum-based chemical processes that harm the environment. Kingdomway's **CoQ10** uses fermentation with *Rhodobacter sphaeroides* exposed to a carbon and oxygen source for an allotted period, to produce CoQ10-containing bacteria, CO₂, and lactate (Xiamen Kingdomway, 2023).

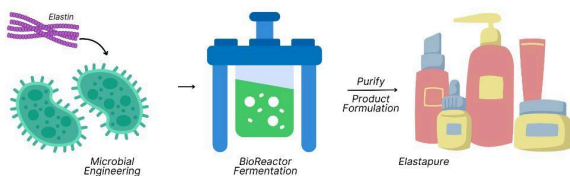
HumaColl21 Production



Lactic Acid Production



Elastapure Production



CoQ10 Production

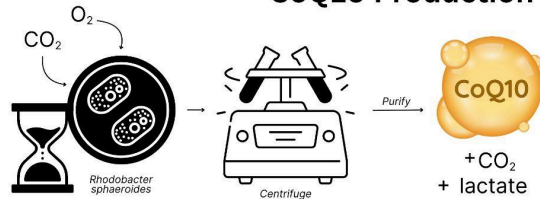


Figure 5. Biotechnologically Derived Ingredients from Pure Culture (Figure generated using canva.com)

3.2.2. Packaging & Waste Reduction

Filipino consumers thoroughly consider sustainable packaging in their cosmetic purchasing decisions, underscoring the shift to green-based practices (Montes et al., 2022). Pure Culture follows suit by avoiding plastics and using upcycled tarpaulin for their mailer bags.

Maupin (2018) states that the market's oversaturation results in a trial-and-error frenzy by consumers, leading to a cumulative loss of \$100,000 and tons of waste. With 13,700+ cosmetic (Statista, 2025) establishments in the Philippines, local consumers experience identical decision fatigue — falling victim to wasted products if they choose incorrectly.

AI allows for a personalized purchasing model instead — enhancing sustainable practices and customer satisfaction (Hash et al., 2025):

- (1) AI provides virtual try-on experiences for cosmetic products to see how it blends on their skin.
- (2) AI chat-based assistance allows consumers to input their

concerns and receive product suggestions best suited for them (Lyanlie Winarto & Anggara Wisesa, 2024; Hegde et al., 2023).

3.3. Challenges and Limitations

While AI helps in maximizing sustainability efforts, its regulation is unclear considering the country's shortcomings in biotechnology integration.

The Philippines is a biotech leader in agriculture, but such success hasn't expanded to other industries. Present legislations like the Food Safety Act of 2013, Republic Act No. 10611, Department of Agriculture Administrative Order No. 08-2002, and the FDA Act of 2009 Republic Act No. 9711 only focus on agriculture. These fail to address the fashion and cosmetics sectors' unique needs, creating hindrances to sustainability efforts. This leaves companies outside agriculture to navigate unclear approval processes. High costs and limited infrastructure also pose challenges for enterprises, further slowing biotechnology integration.



Local resources and traditional knowledge are also at risk of being exploited. While the Indigenous Peoples' Rights Act of 1997, Republic Act No. 8371, is in place, its implementation is inadequate — risking unfair benefit-sharing to local communities.

4. CONCLUSIONS & RECOMMENDATIONS

Innovations from Bakong, Piñatex, Bananatex, and Pure Culture prove the successful utilization of biotechnology in commercially viable and sustainable products. Integrating AI with present biotech practices is a perfect combination for more sustainable markets. To support this growth, industry-specific regulations modeled after the ASEAN Cosmetics Committee standards can ensure alignment with sustainability goals and ease market entry. Intellectual property laws must also specify fair benefit-sharing to guarantee indigenous communities are fairly compensated. Moreover, testing facility investment would address the lack of infrastructure for validating bioengineered materials.

Such solutions are a prerequisite to the future we work towards, but once addressed, the Philippines can become a global leader in sustainable fashion and cosmetics — waiting for the rest of the globe to follow.

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