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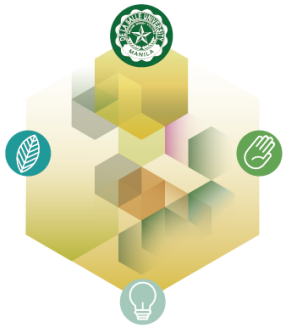

The Current Scenario, Challenges and Opportunities of Biotechnology in the Philippines

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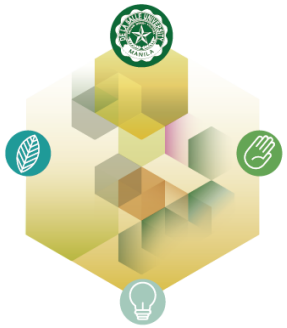
Abstract: This review paper represents the first comprehensive compilation of advancements in the field of biotechnology in the Philippines, aiming to provide a status update, highlight gaps, and identify challenges that must be addressed to foster growth and innovation in both research and commercial applications. With early contributions and initiatives, the Philippines is recognized as a regional leader in biotechnology with significant applications in medicine, agriculture, cosmetics, and other emerging industries. To gather relevant information, extensive searches on local and foreign government and university databases and reputable news outlets were conducted. The paper focuses on both–the use of traditional biotechnology in local and indigenously developed medicines including herbal supplements, and the use of modern biotechnology approaches in the agriculture field comprising genetically engineered crops, biofertilizers, and biopesticides. Biotechnology has also been used for the bioremediation of contaminated sites in the country, with research on actively identifying potential bacterial, fungal, and plant bioremediation agents. Products of biotechnology can be identified in various areas ranging from local drugstores to aesthetic clinics, and clothing stores, further emphasizing its wide application and importance. The purpose of such evaluations is to provide a critical analysis that can help stakeholders develop a strategic action plan with recommendations for the effective use of biotechnology in various areas to address pertinent issues in the environment, agriculture, and healthcare. Focusing on the latest biotechnology advancements in the Philippines, this review paper aims to become a useful resource for researchers, policymakers, and industry leaders to leverage and expand the country's biotechnology capabilities.

Key Words: Philippine biotechnology; agriculture; cosmetics; medicine; emerging industries



1. INTRODUCTION

Biotechnology-based industries had an annual growth rate of 1.3% from 2015 to 2020, leading to a substantial increase in the industry's value that amounts to $295 billion (Martin et al., 2021). Despite Southeast Asia accounting for only 6% of global biotech firms, the Philippines has emerged as a pioneer in biotech breakthroughs within the region (Dorockis & Boguś, 2014). The country was the first in the region to establish a biotechnology regulatory committee; the first to approve the commercial cultivation of Bt corn; and the second, globally, for Bt eggplant (Corpuz, 2020; Mojica-Sevilla, 2022; Bureau of Plant Industry, 2008a). However, the Philippines still lags behind other ASEAN nations' research and development investments (UIS, 2023).

The country's rich plant biodiversity has facilitated the development of medications, supplements, and cosmetics, which are now commercially available. Over the years, the demand for natural and organic products has boosted the innovative drive to develop and market biotechnology products locally. However, there is a need to anthologize all the relevant information related to the biotech sector concerning its research status and industrial use in the country. This paper aims to present the current trends and emerging industries in Philippine biotechnology and identify the gaps and challenges the country needs to address in order to advance in the fields of medicine, agriculture, cosmetics, and the environment using biotechnology. To the best of our knowledge, this review paper is the first to highlight the state of biotechnology in the Philippines, and it is intended to serve as a valuable resource for stakeholders interested in the country's biotech sector.

2. METHODOLOGY

All information on locally available biotech products and processes was collected through various local and foreign government and university databases, as well as news articles published by government agencies and reputable news outlets. These databases were provided by the Bureau of Plant Industry (DA-BPI), United States Department of Agriculture (USDA), Food and Agriculture Organization of the United Nations (FAO), International Trade Administration (ITA) U.S. Department of Commerce, National Institute of Molecular Biology and Biotechnology University of the Philippines-Los Baños (BIOTECH-UPLB), Department of Health (DOH), and International Service for the Acquisition of Agri-biotech Applications (ISAAA). Data obtained from relevant product websites were validated with information from these databases and peer-reviewed journals to ensure accuracy and reliability.

3. RESULTS AND DISCUSSION

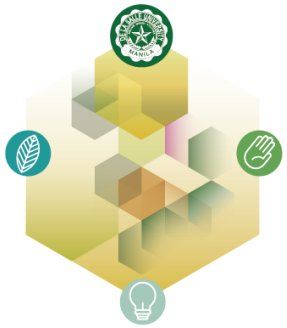
With a strong focus on agriculture, healthcare, and the environment, the Philippines has made significant strides in the development and commercialization of biotech products, which is presented and discussed in the following sections.

3.1 Biotechnology in the Medical Sector

While there are international drug manufacturing companies such as Pfizer and GlaxoSmithKline, the country boasts several locally established pharmaceutical companies, such as Hizon Laboratories, the very first Philippine pharmaceutical manufacturing company, founded in 1898 (Hertez, 1999). Other notable companies include United Laboratories (UNILAB), Pascual Laboratories, and Lloyd Laboratories.

Since the country lacked resources to establish and use modern biotechnology approaches, the focus remained on traditional biotechnology to lay the foundation for indigenous and alternative medicines. The National Integrated Research Program on Medicinal Plants (NIRPROMP) has formulated various drugs and medications in line with the DOH-approved ten plant species for therapeutic use (Appendix 1). These include the lagundi tablet and syrup, sambong tablet, and akapulko antifungal lotion among others. Local pharmaceutical companies and educational institutions have also developed drugs and supplements using serpentina, banaba, and tawa-tawa (PCHRD, n.d.). The use of traditional medicine in combination with biotechnology has opened new avenues for the pharmaceutical industry, enabling the development of natural and cost-effective treatments for various ailments.

Through biotechnology, unique products such as the Tiki-tiki syrup derived from rice bran extract and moringa supplements have been made commercially available (Stuart Jr., 2014; Palada, 2017). Biotechnology has the potential to significantly improve healthcare in the country in the areas of diagnostics, vaccines, and



therapeutics. Filipino scientists developed diagnostic kits for dengue and COVID-19 called BioTek-M Dengue Aqua and GenAmplify™ COVID-19 rRT-PCR kit, respectively (PCHRD, n.d.). More recently developed, the BioTek-M Trio Kit can detect Leptospirosis, Salmonella, and Schistosomiasis, which are neglected tropical and seasonal diseases in the country (Castillo, 2022). On the other hand, detection kits for tuberculosis and human immunodeficiency virus (HIV) drug resistance, as well as other communicable diseases are ongoing (PCHRD, 2021, 2022). These locally-made diagnostic kits are cheaper and more accessible than their imported counterparts.

3.2 Biotechnology in the Agriculture Sector

In recent years, the Philippines has made significant investments in biotech research and development, particularly in crop improvement and bioprocessing. The Philippines has approved nine genetically engineered (GE) crops for use as food or feeds, namely alfalfa, canola, cotton, eggplant, maize, potato, rice, soybean, and sugar beet (ISAAA Inc., 2023) (Appendix 2). GE eggplant, maize, and rice were previously approved for commercial cultivation. GE eggplant and GE maize exhibit insect-resistance and herbicide-tolerant properties (ISAAA Inc., 2019, 2022). The Philippines is also the first country to approve the commercial production of Golden Rice, a GE rice variety fortified with beta-carotene to address the malnutrition issues in the Filipino population (ISAAA Inc, 2021).

Despite these developments, a petition against the commercial release of GE rice and eggplant was filed last October 2022 by the farmer-led organization, Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura (MASIPAG) due to environmental safety reasons (Supreme Court of the Philippines, 2023). In April 2023, the Supreme Court issued a writ of Kalikasan temporarily halting its commercial propagation. The court then ordered the DOH, DA, DENR, DA-BPI, Philippine Rice Research Institute (PhilRice), and UPLB to respond to the petitioners' concerns.

In addition to biotech crops, biofertilizers, and biopesticides serve as economically viable, effective, and sustainable alternatives to their chemical counterparts (Appendix 3). Developed by BIOTECH-UPLB (n.d.), Bio-N, BioGroe, and WiltCure are some of their commercially available biofertilizers and biopesticides. The same institution has also developed the feed supplement ImmunoDefense to boost the immunity and growth performance of aquaculture animals and livestock (BIOTECH-UPLB, n.d.; UPLB-OVCRE, 2018). The Department of Agriculture (DA) has also actively prioritized domestic biofertilizers in local farming communities (DA Communications Group, 2022; Sevillano, 2023).

The sector still faces a number of challenges that need to be addressed in order to fully realize its potential. In 2015, the Philippine Supreme Court prohibited the cultivation of GE crops (Ponce de Leon et al., 2019). This was lifted in 2016 due to appeals from researchers and Bt corn farmers (Pangilinan & Bagunu, 2015; Gonzalvo et al., 2022). Recent developments in Golden Rice and Bt eggplant, however, have led to the prohibition of their commercial cultivation. Agriculture and advocacy groups cite the lack of consumer market for Golden Rice and the biosafety risks associated with both crops to be of major concern (Glover & Stone, 2020; Supreme Court of the Philippines, 2023). Further, the apprehensions about the safety and long-term effects on health due to the consumption of GM crops among Filipino consumers need to be properly addressed.

3.3 Biotechnology in the Cosmetics Sector

One of the areas where the use of biotechnology can be of great commercial importance is the cosmetic industry, where both domestic and international markets have significant potential. For example, botox is a cosmetic form of botulinum toxin derived from the bacterium *Clostridium botulinum* to eliminate wrinkles (Satriyasa, 2019). Biotechnology has also enabled other popular dermatological procedures such as dermal fillers, absorbable threads, IV therapies, exosome applications, and skincare ingredients such as niacinamide, hyaluronic acid, salicylic acid, and retinol (ITA U.S. Department of Commerce, 2022).

In response, local cosmetic companies are integrating these active ingredients to produce high-quality products (Gomes et al., 2020). With the increasing popularity of active ingredients and non-invasive skin treatments from biotechnology, the beauty industry in the Philippines will likely continue to embrace the latest biotech advancements to create products that provide better consumer outcomes.

3.4 Biotechnology and the Environment

As one of the world's most threatened biodiversity hotspots, it is necessary to develop strategies to preserve the ecosystems in the country. With the main goal to reduce greenhouse gas (GHG) emissions, the Philippines is a pioneer, being the first

country in Southeast Asia, to implement legislation on biofuels (Montefrio & Sonnenfeld, 2011). The Biofuels Act enacted in 2007 mandates the blending of 5% biodiesel, derived from coconut oil, and 10% bioethanol, obtained from sugarcane and molasses, to fossil fuels used in land transport (Acda, 2022). Other feedstocks are currently explored: jatropha for biodiesel; and corn, cassava, and sweet sorghum for bioethanol (Acda, 2022; Montefrio & Sonnenfeld, 2011). The debate between food security and biofuel arises as the dedication of land area and use of agriculturally-important crops as biofuel feedstocks can negatively influence food production and prices (Montefrio & Sonnenfeld, 2011). At present, biofuels only account for 1.4% of total energy consumption in the country, and the Biofuels Act remains ineffective as it fails to meet its goals (Acda, 2022).

Microalgae are photosynthetic microorganisms considered as third-generation feedstock found to have the highest biodiesel potential yield in the country (Landoy et al., 2022). It is a promising feedstock candidate as it grows fast and has high oil content up to 77% depending on the genus, can be conveniently grown in a bioreactor thus obtaining high yield, and does not compromise food security (Chen et al., 2018; Christi, 2007; Janaun & Ellis, 2007). Several microalgae genera were found to be suitable bioethanol feedstock, including *Chlorella*, *Scenedesmus*, and *Spirulina* among others (Culaba et al., 2020). In particular, *Chlorella vulgaris* is a promising feedstock for biodiesel production (Landoy et al., 2022). Despite the promising technology, microalgae oil extraction is not yet conducted at large scale (Landoy et al., 2022); and it scored higher in the environmental impact category in a life cycle assessment due to its electricity consumption (Ubando et al., 2017).

While the use of microalgae-derived biodiesel entails lower GHG gas emissions than petroleum diesel (Landoy et al., 2022), the electrical power required in every step of biodiesel production using microalgae cultivation system is the one that largely contributes to GHG gas emissions (Ubando et al., 2017). Production of microalgae-derived biodiesel alone is therefore environmentally and economically inefficient (Culaba et al., 2020).

Though bioremediation approaches have not been utilized to their full potential, there have been successful applications of this technology. Bioremediation activities have been conducted in Maytunas Creek in Mandaluyong City and Laguna de Bay using an effective microorganism (EM) solution to improve water quality (EMB-NCR, 2021; Allanigue, 2023). In *Estero de San Miguel*, Manila and in fishponds in Bulacan, phytoremediation strategies using mosquito fern, water hyacinth, and vetiver grass have been employed (Acero, 2019; Pleto et al., 2019). Microbial biofertilizer has also been used to rehabilitate an abandoned mining site in Mogpog, Marinduque (Arayata, 2019).

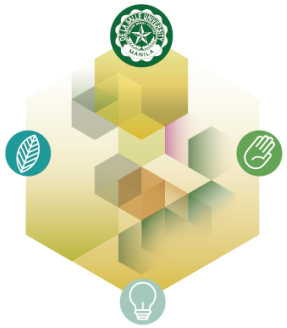
Philippine studies assessing contaminated sites to identify the potential of various bacteria, fungi, and plants as bioremediation agents serve as a valuable resource in identifying potential bioremediation techniques. More research and development in this field can help identify more effective and sustainable bioremediation strategies that can be applied to address environmental contamination issues in the Philippines.

3.5 Emerging Industries

There are certain areas where the use of traditional biotechnology can be explored to bring more revenue to the country, such as the textile industry. The Philippine Textile Research Institute (PTRI) is involved in promoting the utilization of Philippine tropical fabrics (PTF), which contain natural fibers from plants such as abaca, pineapple, and Philippine varieties of silkworm (Caoili, 2019). In 2021, the local production of abaca reached 67,488 metric tons (mt) (Talavera, 2022), generating a total export revenue of PhP 1.57 billion (PSA, 2022). Statistics on the production of other natural fibers are published monthly by PhilFIDA, but data for the export of other natural fabrics are unavailable.

Continuing with traditional biotechnology, sericulture for the production of raw silk is being promoted in the country (PhilFIDA, 2018). Over 100 pure and hybrid silkworm strains are being maintained at sericulture centers nationwide (Catalma et al., 2021). Four new hybrid strains of Philippine silkworms have recently been developed and are undergoing field verification trials (PTRI, 2021).

In addition, the PTRI has identified over 100 natural plant dye sources, which include indigo (*Indigofera tinctoria*) for blue/indigo dye; annatto (*Bixa orellana*) for red/orange; and mahogany (*Swietenia macrophylla*) for reddish brown (Arayata, 2023; Palasi, 2022). The same agency is also responsible for the 10 NatDyes Facility and Production Hubs across the country, which provide access to natural dye technologies and facilities to communities (PTRI, n.d.). To further promote the industry, ready-to-buy natural yarns, and natural dye kits are available for purchase in DOST-PTRI (PTRI, 2020).



Biotech products also found their way to help the livestock industry of the country. A vaccine against hemorrhagic septicemia, a deadly disease in cattle, carabao, and other ruminants, was developed using the bacteria *Pastreurella multocida* (Maslog, 1998). In addition, existing vaccines namely, BIOVAC FC for fowl cholera and BIOVAC IC for infectious coryza in chicken, have been developed by UPLB-BIOTECH (n.d.-a). Currently, the institution is working on a new fowl cholera vaccine and a vaccine against *Streptococcus suis* infection in swine. Various research was also conducted in the production of a polyvalent vaccine against common ruminant bacterial infections such as *Staphylococcus* sp., *Streptococcus* sp., *Corynebacterium* sp., and *P. multocida* (UPLB-OVCRE, n.d.-a).

The country has also made significant strides in enzyme biotechnology. Through fermentation of certain microbes, industrial enzymes such as α-amylase, cellulase, glucoamylase, pectinase, protease, and xylanase, are produced, with a variety of applications, ranging from food and beverages, feed additives for livestock, ethanol production, to cleaning detergents (UPLB-OVCRE, n.d.-b).

Biorefinery systems yield value-added products from a single raw material (Chew et al., 2017). Integration of biorefinery infrastructures into algal cultivation systems paves an opportunity to maximize output and profit, while simultaneously mitigating GHG emissions (Chew et al., 2017). Biorefinery models utilizing microalgae as the raw material were enumerated by Culaba et al. (2020). For instance, while producing biodiesel and bioethanol as main products, value-added products co-produced include hydrogen, carbohydrates, fatty acids, proteins, pigments, fertilizers, and biochemicals, with wide applications ranging from the fermentation, pharmaceutical, and chemical industries (Culaba et al., 2020; Chew et al., 2017).

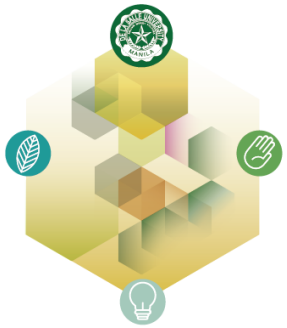
In relation, the DOST-National Research Council of the Philippines (DOST-NCRP) developed a process graph to utilize agriculture wastes, particularly rice bran, straw, and husk, and corn stover into biofertilizers and bioenergy products (Benjamin et al., 2021). This framework illustrates the optimum strategies to maximize profit and to elevate the use of agricultural biomass. Another fuel crop, sugarcane, and its agricultural byproduct, molasses, have been utilized in the production of bioethanol (Demafelis et al, 2020). While a sugarcane bioethanol production facility may be efficient, energy-wise, its vast water requirements inhibits its sustainability and appeal to investors. The large-scale use of such crops may boost the income of farmers and agricultural industry players, following an increase in the demand for such biomass and residues. However, the projected water consumption of such biorefinery facilities, and combining this with the country's harsh dry season, may compete with the water resources allocated for agricultural use.

3.6 Current Biotechnology Initiatives in the Philippines

The Philippine Department of Agriculture (DA) mainly oversees biotechnology research in the country under its constituent offices. One of the main projects of DA is the Biotechnology Research for Development (R4D) program, which supports basic and applied research in crop, animal, and fisheries biotechnology. The transfer and adoption of technologies to relevant stakeholders such as farmers, fisherfolk, and agribusiness entrepreneurs are covered in the projects called Community-based Participatory Action Research and National Technology Commercialization Program (DA-BAR, n.d.).

Specific biotechnology research endeavors are pursued by offices under the DOST, including the Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD), Philippine Council for Industry, Energy, and Emerging Technology Research and Development (PCIEERD), and PCHRD, together with the Institute of Molecular Biology and Biotechnology of the UP System and other universities. Ongoing projects of these agencies are enumerated in their respective websites. All these stakeholders need better coordination and a proactive approach to strengthen the research and innovation in the country's biotechnology field.

Considering the logistics of the use of biotechnology products and processes in the country, similar to other commercial and trade products, the Philippine shipping and transportation industries are crucial to ensure future success. Since the country is an archipelago, inter-island transportation is the main method to facilitate the delivery of domestic goods and provide transportation for people across numerous islands. The country is dependent on domestic aviation freight and road networks to support its many islands (Zenhub, 2023). Furthermore, its geographic position is advantageous making it a prime hub for logistics businesses, with the freight and logistics market expected to grow at a rate of over 7% by 2027 (Mordor Intelligence, 2023).. As highlighted by the Asian Development Bank (2012), some issues in the logistics



sector are road network quality, intermodal planning and integration, governance and institutional capacity, urban transport infrastructure, and private sector provision of infrastructure. Thus, there has to be a seamless transport network to enable the cost-efficient movement of biotechnology goods and services within the country. It would be prudent to explore the use of autonomous technology, such as drones to develop the local and internationally connected logistics ecosystem in the country.

3.7 Regulatory Bodies and Policies

Recognizing the long-term impacts of biotechnology applications across various industries, the Philippines established the National Committee on Biosafety of the Philippines (NCBP) through Executive Order No. 430 in 1990 (Bureau of Plant Industry, 2008). The committee is the primary regulating body in evaluating the hazards of GE experiments and products and creating national policies and risk assessment guidelines. The application forms for using GE products and their respective issuance procedure are readily available on the NCBP website, thus helping biotech companies better navigate the country's regulatory landscape. Likewise, it would be helpful to publicize updated policies on the cultivation and sale of such products. This enables citizens to make conscious decisions regarding biotech products available in the market.

Due to the United Nation Cartagena Protocol on Biosafety, the National Biosafety Framework was established in 2006 to ensure multi-sector collaboration on developing biosafety protocols. (Bureau of Plant Industry, 2008b, 2021). Its implementation emphasizes the importance of preserving local biodiversity and consumer well-being as the country adopts biotechnology innovations.

4. CONCLUSIONS

Overall, the Philippines promotes the use of biotechnology in various industry sectors. The Philippines' medical, agriculture, and cosmetics sectors, as well as other emerging industries integrate biotechnology to improve the quality of products and services. Plant-based alternatives dominate biotech developments in the medical sector. The availability of GE crops and biotech-based pesticides and fertilizers provide accessible routes to sustainable agriculture. The interest in cosmetics and textiles will continue to grow simultaneously with innovative products using natural ingredients and biotechnology by-products. While the country employs limited bioremediation activities, growing interest in potential bioremediation agents opens the possibility for its expanded use in the future. Aside from this, the creation of bioproducts can be improved if the Philippines employs a simultaneous production scheme such as a biorefinery, contributing to the country's sustainable production and circular economy.

Despite government initiatives to promote biotech research and development, funding for biotech startups and research projects is significantly less than in neighboring countries. This has resulted in a lack of innovation and a slow pace of development in the sector. Apart from this, there may be logistical constraints due to the archipelagic structure of the country. Moreover, there is a need to involve stakeholders, such as farmers and consumers, when creating policies related to GE products. This likewise ensures that a stable market is available for the intended biotech-related products .

Investing in up-to-date databases is also crucial to improve the accessibility and awareness of Filipinos to commercially available biotech innovations. As the biotechnology field continues to expand, the country must continue to invest in its initiatives and agencies to keep up with global biotech trends.

5. ACKNOWLEDGMENTS

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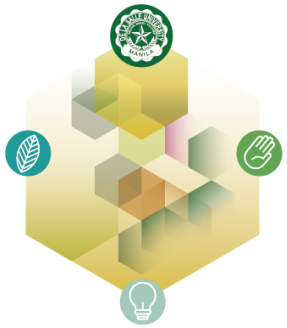

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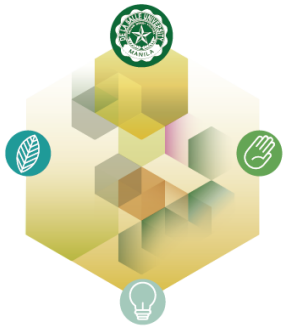

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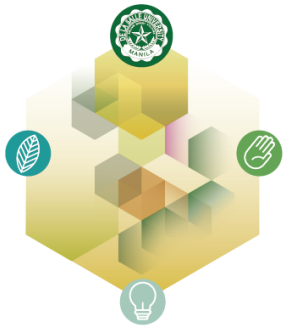

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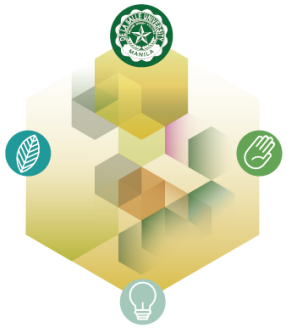


APPENDICES

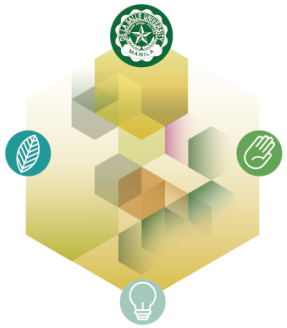
Appendix 1. Some Philippine medicinal plants (PCHRD, n.d.).

Local Name	Scientific Name	DOH approved?*	Commercially available?	Formulation	Treatment for/Uses
lagundi	*Vitex negundo*	✓	✓	tablet/syrup	common respiratory tract infections
sambong	*Blumea balsamifera*	✓	✓	tablet	anti-urolithic; diuretic
tsaang-gubat	*Carmona retusa*	✓	✓	tablet	diarrhea; gastrointestinal and biliary colic pain
akapulko	*Cassia alata*	✓	✓	lotion	antifungal
yerba buena	*Clinopodium douglasii*	✓	TRL 9	tablet	analgesic
ulasimang-bato	*Peperomia pellucida*	✓	TRL 7	tablet	anti-hyperuricemic; anti-inflammatory
bignay	*Antidesma bunius*	×	✓/ TRL 9	capsule	food supplement; lung anti-inflammatory
serpentina	*Andrographis paniculata*	×	TRL 8	capsule	antioxidant; anti-inflammatory
banaba	*Lagerstoemia speciosa*	×	TRL 8	tablet	blood sugar level reduction
tawa-tawa	*Euphorbia hirta*	×	✓	capsule	reduce dengue symptoms

*Included in the list of 10 DOH-approved medicinal plants
TRL classifications are explained in the Technology Application and Promotion Institute website (http://www.tapi.dost.gov.ph/call-for-proposals/technicom)

Appendix 2. Initial Genetically Engineered Crops Approved for Use in the Philippines (ISAAA Inc., 2023).

Crop Name	Scientific Name	Function	Usage Type	Approval Date	Trade Name
Alfalfa	*Medicago sativa*	Herbicide tolerance	Food and Feed	2006	Roundup Ready
Canola	*Brassica napus*	Herbicide tolerance	Food and Feed	2003	Roundup Ready
Cotton	*Gossypium hirsutum L.*	Herbicide Tolerance	Food and Feed	2003	Roundup Ready
		Insect Resistance	Food and Feed	2003	Bollgard II
Eggplant	*Solanum melongena*	Insect resistance	Food and Feed, Cultivation	2022	BARI Bt Begun-1, -2, -3 and -4
Maize	*Zea Mays L.*	Insect resistance	Food and Feed, Cultivation	2002	YieldGard, MaizeGard
Potato	*Solanum tuberosum L.*	Insect resistance	Food and Feed	2002	New Leaf Russet Burbank
		Insect resistance, disease resistance	Food and Feed	2003	Shepody New Leaf
Rice	*Oryza sativa*	Modified Product Quality	Food and Feed, Cultivation	2021	Golden Rice
Soybean	*Glycine max L.*	Herbicide tolerance	Food and Feed	2003	Roundup Ready



Sugar beet	*Beta vulgaris*	Herbicide tolerance	Food and Feed	2005	Roundup Ready

Appendix 3. Commercially Available Agricultural Biotech Products (BIOTECH UPLB, n.d.; UPLB-OVCRE, 2018).

Product Name	Product Type	Benefits
Bio N	biofertilizer	enhance nitrogen availability
NitroLink	biofertilizer	enhance nitrogen availability
BioGroe	growth promoter	promote root growth; enhance plant immunity
Brown Magic	biofertilizer	promote growth and protects against diseases; for orchids
BioPlasma	microbial inoculant	protect against cassava phytoplasma disease (cpd); for cassava
BioSol-P	microbial inoculant	enhance phosphorus availability
K-SolB	biofertilzer	enhance potassium availability
Maizinc	microbial inoculant	enhance zinc uptake; for maize
Micromix	biostimulant	for bell peppers and bitter gourd
Fermented Plant Juice	liquid fertilizer	enhance fruiting and yield
Mycogroe	biofertilizer	for forest trees and commercial plantations
MykoPlus	growth promoter	enhance water and nutrient absorption
Mykovam	biofertilizer	enhance water and nutrient absorption
NitroPlus	microbial inoculant	enhance nitrogen availability; for legumes
Nutrio	biofertilizer	enhance growth and yield; for sugarcane and eggplant
Oryzinc	microbial inoculant	enhance zinc availability
PhosphoLink	microbial inoculant	enhance phosphorus availability
VAMRI	mychorrizal root inoculant	enhance absorption of water and nutrients
WiltCure	biopesticide	protect against fusarium wilt
ACTIcon	biopesticide	protect against fusarium wilt; for cavendish bananas
Pelmictrol	microbial insecticide	prevent growth of mosquito larvae
Bactrolep	microbial pesticide	protect against Asian corn borer, diamond backmoth, crucifer pests
ImmunoDefense Aqua	feed supplement	Boost immunity, improve growth, reduce antibiotic use; for aquaculture animals
ImmunoDefense for Swine and Poultry	feed supplement	Boost immunity, improve growth, reduce antibiotic use; for swine and poultry