Canarium ovatum Engl.: The Next Wonder Tree of the Philippines

Jessica D. Rey
University of the Philippines Diliman
jdrey@up.edu.ph

Cedrick V. Alguzar
University of the Philippines Diliman
cvalguzar@up.edu.ph

ABSTRACT

Canarium ovatum Engl., commonly known as pili or pili nut, is a tropical nut-bearing tree that has high economic importance and has been recognized as a potential export commodity worthy of intensive research and development activities primary because almost all of its parts can be utilized for the production of agricultural, commercial, industrial, pharmaceutical, and cosmeceutical products. However, this tree along with its relatives in the genus *Canarium* L., is still very much underutilized and understudied. This paper presents the existing scientific knowledge on the morphology, ecology, propagation, uses, phytochemistry, and pharmacology of pili, as well as the current status of its industry to emphasize the many possible uses of the tree. Possible research and development opportunities on pili were also considered to better understand its biology, which will be of great use in strengthening its growing industry towards being the next wonder tree. We propose here the opportunity to use in vitro propagation.

Keywords: Canarium ovatum Engl., economic importance, pili nut industry, research and development opportunities, in vitro propagation

Introduction

Canarium ovatum Engl., commonly known as pili or pili nut, is an evergreen tree that belongs to the resinous family of flowering plants Burseraceae. It is one of the approximately 75 tropical and subtropical tree species of the genus *Canarium* L. that has indigeneity in the Philippines, with the Bicol Region as the center of its genetic diversity (Coronel 1996; Rashid et al. 2021).

Pili is a nut-bearing tree that has high economic importance because of its several uses. Its fruit has an edible kernel and pulp, which can be processed into various delicacies. The hard and stony shell of its fruit can be used as an ornament and be made into a fuel for cooking. The pili tree itself is a good source of resin, firewood, and house-framing materials (Coronel 1996; Gallegos et al. 2013). Furthermore, pili is a rich source of phytochemicals that exhibit several biological activities such as antioxidant, antimicrobial, anticancer, immunomodulatory, and cytotoxicity (Silalahi and Wakhidah 2020). It is also relatively free from pests and diseases (Coronel 1996) and serves as a good host for a variety of fungal endophytes that have antibacterial activity (Torres and dela Cruz 2015). Because of this, pili nut tree has been recognized as an economically important crop worthy of intensive research and development activities (Gallegos et al. 2013).

However, despite its commercial value, a comprehensive review on *Canarium ovatum* Engl. is still not available. Hence, in this paper, updates on the morphology, ecology, propagation, uses, phytochemistry, pharmacology, and possible research opportunities on pili are discussed. This information will be of great importance to all pili growers and breeders, researchers from different academic and research institutions conducting studies on pili nut, and policymakers in areas where production of pili products is practiced.

Morphology

Pili is a large deciduous tree that may reach up to about 35 m height and a trunk diameter of 50 cm or more. Its leaves are alternate and spirally arranged along the stem and have a length of about 30 cm. Leaves are also imparipinnate, with three pairs of smooth leaflets that consist of 8-12 pairs of veins and are ovate-oblong, 12-20 cm long, 3-7 cm wide, and acuminate at the apex but rounded at the base (Coronel 1996; Pham 2016; Silalahi and Wakhidah 2020).

Flowers are of a cymose type and exhibit axillary inflorescence. Female trees have 3-6 flowers on each inflorescence that are about 7 cm long, while male trees have about 18 flowers in an inflorescence that are approximately 10 cm long. Furthermore, female flowers have saccate and gamosepalous calyx consists of three thick, light green sepals; they also have three greenish-yellow petals, six sterile stamens, and a 7-mm long pistil with a simple style, a three-lobed stigma, and a trilocular ovary with two ovules each locule. Male flowers, in contrast, have saccate calyx composed of three green sepals tinted with yellow-orange at the tips, three ovate, greenish petals, six functional stamens, and a greatly reduced pistil with a vestigial ovary. Hermaphroditic flowers are also seen in some male trees; they are similar to the male flowers but both pistil and stamen are functional (Coronel 1996; Orwa et al. 2009).

The pili fruit, which is generally regarded as pili nut, is an ovoid to ellipsoid drupe that is 4-6 cm in length and 2.3-3.8 cm in diameter. It has three general parts, namely: the skin, the pulp, and the nut. The skin (exocarp) is thin and glabrous; it surrounds the pulp and turns from light green to purplish-black upon ripening. The pulp (mesocarp) that surrounds the nut is fibrous and fleshy, while the nut has a hard and stony shell that protects the seed. The trigonous shell (endocarp) is brownish and elongated. Its basal end is pointed but is blunt or obtuse at the apex. The seed is then enveloped by a thin, brownish, and papery seed coat (testa). It has two whitish cotyledons (i.e. the kernels) that surround the embryo and constitutes 4.4-16.6% of the whole fresh fruit (Coronel 1996; Orwa et al. 2009; Pham 2016).

Distribution and Ecology

Canarium ovatum Engl. is endemic in the Philippines. It is mainly cultivated in the Bicol Region, but it is also found in other regions such as Cagayan, Cordillera, Southern Tagalog, Eastern, Western and Central Visayas as well as Southern Mindanao (Coronel 1996; Silalahi and Wakhidah 2020). It is also grown in other countries such as Indonesia, Hawaii, Africa, and Brazil (Coronel 1994; Ogbuagu and Chikuka 2015; Silalahi and Wakhidah 2020).

Pili is a tropical tree that naturally grows at low to medium altitudes in primary and secondary forests. However, it also grows well over a wide range of conditions. It can thrive in various soil types, from very acidic soil to an elevation of 400 m above sea level. For optimal growth, pili trees are planted in deep, fertile, and well-drained soil. Moreover, pili can adapt well to diverse climatic conditions. Aside from areas with well-distributed rainfall, it also grows well in places with distinct dry and wet seasons as well as locales frequently hit by typhoons and strong winds (Coronel 1996; Orwa et al. 2009; Silalahi and Wakhidah 2020).

Propagation

Pili is a dioecious tree (n=23) that can be cultivated through seed propagation or asexual methods such as marcotting, grafting, and budding. When sown, pili seeds germinate after about 30 days and become productive after 5-6 years. Although pili trees are primarily grown using seeds/seedlings, such practice is no longer advised as half of the trees are males, and seedlings exhibit high genetic variability and long juvenile period (Villegas and Coronel 1980; Coronel 1996; Lanting and Palaypayon 2002).

Among the asexual methods, wedge-grafting and patch budding are the two recommended macropropagation practices for pili, which both yield the best results when performed between November and February using defoliated budwoods. However, asexually propagated pili trees have low survival rates and slow productivity periods. Marcotted pili trees have a 0-100% survival rate when sliced off from the mother tree and bear fruits two to three years after planting, with economic yields in the fifth or sixth year. A similar productivity period was seen in grafted pili trees, which have a success rate of about 85%. Budded pili trees, in contrast, have a success rate of 75-80%. Its seeds are also recalcitrant, making them difficult to conserve via the conventional seed bank storage (Coronel 1994; Coronel 1996).

In addition, although pili is commercialized in both local and global markets, pili plantation is only 2,164 ha in 2019 compared to 28,688 ha for cashew (PSA 2020). Bicol, which shares a huge chunk of this area, only has about 142.34 thousand pili-bearing trees (Catelo and Jimenez 2016). This lack of supply and efficient propagation method of pili serve as the major obstacles in establishing its industry (Sui 1995; DOST 2019). Thus, a new and efficient propagation method, which could serve as an alternative or a supplement to its existing macropropagation practices, is needed for its germplasm conservation and commercialization. In this regard, the in vitro propagation or the use of tissue culture technology could be explored.

Economic Uses

Pili is the most economically important *Canarium* L. species in the Philippines primarily because almost all of its parts can be utilized for the production of agricultural, commercial, industrial, pharmaceutical, and cosmeceutical products. Both the kernel and pulp of its fruit are edible and can be processed into various delicacies such as candies, salads, cakes, puddings, and ice cream (Gallegos et al. 2013; Pham and Dumandan 2020). They also contain a high nutritional value; both are good sources of minerals, dietary fibers, proteins, and oils (Marcone et al. 2002; Ogbuagu and Chukwuka 2014; Ogbuagu and Chukuka 2015; Oluwaniyi et al. 2017; Millena and Sagum 2018a, b; Millena et al. 2021). The oils obtained from pili pulp and kernel contain significant levels of fatty acids such as oleic, linoleic, palmitic, and stearic acids, as well as unsaponifiable matter that is mostly carotenoids, phytosterols, and tocopherols, suggesting that these oils can be of culinary use (Pham and Dumandan 2015; Pham 2016; Pham and Dumandan 2020; Tugay et al. 2020). Utilization of these oil in biofuel production (Bicol and Razon 2007; Barro et al. 2013) and in manufacturing cosmetic products has also been evaluated (Gallegos et al. 2013; Pham 2016). Furthermore, the pili nutshell is used in making ornaments and as a component of the growing medium for orchids and anthuriums. It can also be utilized as a fuel for cooking and be processed into charcoal and activated carbon for water purification, fabrication of a dye-sensitized solar cell (DSSC), and as deodorizing, decolorizing, and filtering agents (Gallegos et al. 2013; Pham and Dumandan 2020; Gasga et al. 2021). The nanocellulose extracted from the waste pili pulp has also been shown to be a potential alternative to mineral-based ingredients for cosmetics (Bongao et al. 2020), while the pigment extracted from the pili exocarp can serve as a functional food colorant for yogurt products (Aril-dela Cruz et al. 2017).

The pili tree itself has many uses. It makes an excellent tree for landscaping and agroforestry. It also serves as a windbreak to other crops because of its resilience to strong winds and typhoons. Moreover, pili tree is a good source of resin, firewood, and house-framing materials as well as for making boxes, crates, and instruments. Its young shoots are also edible and can be made into a salad (Coronel 1996; Pham 2016).

Additionally, some locals use pili as an antirheumatic agent and a remedy to fever, swelling of the legs, and some ulcers (Lanting and Palaypayon 2002; Demetillo et al. 2019). Although it is relatively free from pests and diseases (Coronel 1996), pili also houses a diversity of fungal endophytes, with some having antibacterial activity against certain Gram-positive, Gram-negative, and spore-forming bacteria (Torres and dela Cruz 2015; General and Guerrero 2017). These diverse applications of pili truly wasrrant intensive studies to further understand its biology and its economic potential.

Phytochemistry

Aside from its economic use, pili contains a wide array of nutrients and compounds that are generally bioavailable and have various nutraceutical and pharmacological applications (Pham and Dumandan 2020; Silalahi and Wakhidah 2020). High levels of essential elements such as sodium, potassium, calcium, magnesium, and phosphorus, as well as significant amounts of trace elements, specifically iron, zinc, copper, manganese, aluminum, nickel, and chromium have been detected in its pulp and kernel (Ogbuagu and Chukwuka 2014; Oluwaniyi et al. 2017; Millena and Sagum 2018a). In the study of Arenas and Trinidad (2017a), tolerable limits of the heavy metals arsenic, cadmium, and lead were also identified from the defatted pili pulp meal. Various lipid molecules such as short-chain fatty acids, mono-, di-, and triacylglycerols with fatty acids that are mainly oleic, palmitic, linoleic, and stearic, and traces of linolenic, myristic, lauric, hexanoic, octanoic, and arachidonic acids were likewise determined from the pulp and kernel (Pham et al. 1998; Kakuda et al. 2000; Ogbuagu and Chukuka 2015; Pham and Dumandan 2015; Millena and Sagum 2018b; Millena et al. 2021). Alkaloids, flavonoids, saponins, tannins, terpenoids, sterols, anthraquinones, indoles, phenolic acids, vitamins, amino acids, proteins, carbohydrates, and dietary fibers have also been detected in extracts and oils derived from pili pulp and kernel (Marcone et al. 2002; Ogbuagu and Chukwuka 2014; Ogbuagu and Chukuka 2015; Arenas and Trinidad 2017a, b; Millena and Sagum 2018b; Recuenco et al. 2020; Tugay et al. 2020). Other studies also revealed the presence of antinutrients such as tannic acids, phytates, and oxalates (Oluwaniyi et al. 2017; Millena and Sagum 2018a) as well as the pigment anthocyanin in the fruit (Aril-dela Cruz et al. 2017; Millena et al. 2021).

A number of terpenoids have been identified from the essential oil of *C. ovatum* Engl. resin. Majority of these compounds are monoterpenes such as á-phellandrene and its derivatives, limonene, â-phellandrene, *para*-cymene, carvacrol, piperitone, and á-phellandrene epoxides. Traces of á-elemol and toluene, as well as certain enantiomers of chiral monoterpenes have also been detected. Moreover, the hydrosols obtained from the essential oil contain high concentrations of various volatiles, particularly *cis*-á-phellandrene epoxides, *para*-cymen-8-ol, carvacrol, *para*-menth-5-ene-1,2-diol isomers, and *trans*-6-hydroxy-*para*-menth-1-en-3-one (Mercier et al. 2020).

In a separate study, several sesquiterpenes and triterpenes have been isolated from the methanolic extract of pili resin. These terpenoids include four sesquiterpene alcohols such as cryptomeridiol, 4-epicryptomeridiol, eudesm-4(15)-ene-1â,11-diol, and cadin-1(14)-ene-7á,11-diol, 10 triterpene alcohols which are á-amyrin, 3-epi-á-amyrin, brein, 3-epibrein, uvaol, â-amyrin, 3-epi- â-amyrin, maniladiol, 3-epimaniladiol, and lupeol, and four triterpene acids, specifically 3-oxotirucallic acid, 3á-hydroxytirucallic acid, 3â-hydroxytirucallic acid, and 3á-hydroxytirucalla-7,24-diene-21-oic acid (Kikuchi et al. 2012). Ragasa et al. (2015) also identified various triterpenes from dichloromethane extracts of leaves, twigs, and fruits of pili. Among these are â-amyrin, á-amyrin, epi-â-amyrin, epi-á-amyrin, and epi-lupeol. Carotenoids, which are mainly carotene and lutein, as well as 1,2-dioleoylglycerols have also been recorded. Other unsaponifiable matters identified from pili are â- and á-carotene, zeaxanthin, lycopene, ä-, ã-, and á-tocopherol, stigmasterol, lanosterol, brassicasterol, campesterol, and â-sitosterol (Pham and Dumandan 2015). This abundance of phytocompounds in pili also warrants additional studies that will isolate and characterize the individual phytoconstituents and screen them for biological activities.

Biological Activities

Plants are a rich source of compounds that demonstrate various biological activities (Mogana and Wiart 2011). Different studies have shown that *Canarium ovatum* Engl. possesses several pharmacological and biological activities.

Antioxidant activity. The antioxidant capacity of pili has been demonstrated using in vitro assays. In the study of Cajuday et al. (2017), the ethanolic extract from *C. ovatum* Engl. pulp demonstrated a significantly higher antioxidant activity than pili pulp oil and ascorbic acid (control) in both DPPH (2,2-diphenyl-1-picrylhydrazyl) and FRAP (ferric reducing ability of plasma) assays, with the 10 mg/mL concentration displaying the highest DPPH free radical scavenging activity (1406.34±275.83% at pd"0.05). Ethanolic extracts of leaves also indicated a remarkable antioxidant activity in DPPH assay, with a free radical scavenging activity of 91.99% (Alima and Demayo 2018).

In another study, methanolic extract of pili pulp displayed a higher DPPH free radical scavenging activity (469.3±3.3 mg AEAC/100 g FM) and ferric reducing power (83.1±1.0 mg AAE/100 g FM) than the methanolic extract of the kernel (82.0±6.1 mg AEAC/100 g FM for DPPH assay, and 31.1±0.6 mg AAE/100 g FM for FRAP assay). However, these antioxidant activities exhibited by pili pulp and kernel are relatively lower compared to other plant species tested. Nevertheless, these results still show the potential of pili as a source of natural antioxidants (Recuenco et al. 2020).

When the oils (roasted and unroasted) obtained from the kernel were then investigated for their antioxidant potential, roasted pili nut oil (RPNO) exhibited a higher DPPH scavenging activity (24.66%) than unroasted pili nut oil (UPNO; 9.52%), supporting other studies that pretreatment of the nut with heat alters its chemical composition leading to increased antioxidant activity of roasted oil (Zarinah et al. 2014).

With the antioxidant activity display by different parts and preparations of pili, it can be concluded that it might be a good source of natural antioxidants and in vivo investigations of this observed property are needed.

Anticancer activity. Different parts of pili have demonstrated anticancer activities using various cell lines and model organisms. The anti-angiogenic activity of the ethanolic extract from *C. ovatum* Engl. pulp was demonstrated by Cajuday et al. (2017) using the chorioallantoic membrane (CAM) assay. In their study, significant reductions in the growth of primary blood vessels were observed in samples treated with the highest dose (10 mg/mL) of the extract, while the medium dose (1 mg/mL) decreased the growth of primary, secondary, and tertiary blood vessels, as well as the branch point number ($p=0.05$). Interestingly, although the pili pulp oil did not reduce the blood vessel growth of the duck embryos, morphological observations revealed the presence of blood vessel obstructions such as ghost vessel formation, hyperemia, and petechial hemorrhage in samples treated with 50% and 75% oil. Similar observations have been recorded in all treatments of the ethanolic extract, and by Chan and Cajuday (2013), using aqueous leaf extract of *C. ovatum* Engl.

In another experiment, a dose-dependent genotoxic effect of the *C. ovatum* Engl. bark crude extract has been observed using the *Allium cepa* test. Here, both 0.01 mg/mL and 0.1 mg/mL concentrations of the extract reduced the mitotic index of the onion root tip cells by 80%, while the highest concentration (1 mg/mL) inhibited their mitotic capacity by 100%. These results are statistically different from the positive control Tylenol at $p < 0.01$. Furthermore, a high percentage of chromosomal aberrations such as chromosomal bridges, laggards, sticky chromosomes, vagrant chromosomes, C-mitosis, and diagonal metaphase, along with spindle abnormalities were seen in the samples exposed to *C. ovatum* Engl. bark extracts (Balbuena et al. 2019). Antimutagenic properties of the methanolic extract of the pili leaves, as well as its hexane and ethyl acetate (EtOAc) fractions, were also observed by Chichioco-Hernandez and Paguigan (2009) using the in vivo micronucleus test (MT).

In addition, cytotoxic properties of the *C. ovatum* Engl. ethanolic leaf extract were reported against human colon carcinoma cells (HCT116) and non-small cell lung adenocarcinoma (A549) cell lines, with the IC_{50} of 4.39 ìg/mL and 36 ìg/mL, respectively. Cytotoxicity of pili was also observed by Cajuday et al. (2017) and Balbuena et al. (2019) using the sea urchin fertilization assay. However, both RPNO and UPNO did not exhibit effects against HeLa (cervical cancer cell), MCF-7 (breast cancer cell), and HT-29 (human colon adenocarcinoma cell) cell lines, with an IC_{50} value of more than 30 ìg/mL after 72 h of treatment (Zarinah et al. 2014). Such contrasting results may indicate the differences in chemistry of the plant parts used and warrants further investigation.

Antibacterial activity. The available literature on the antibacterial activity of pili is limited. The roasted and unroasted pili nut oils in the study of Zarinah et al. (2014) were also able to reduce the growth of various bacterial species, including *Klebsiella pneumoniae*, *Salmonella typhimurium*, *Salmonella choleraesuis*, *Staphylococcus epidermidis*, *Serratia marcescens*, *Bacillus cereus*, *Escherichia coli*, *Enterobacter cloacae*, *Enterobacter aerogenes*, and *Pseudomonas aeruginosa*, but failed to display any effects on *Yersinia enterocolitica, Listeria monocytogenes*, *Bacillus subtilis*, and *Staphylococcus aureus*. However, methanolic extracts of pili pulp and kernel as well as essential oils and hydrosols from its resin demonstrated antibacterial activity against the Gram-positive *S. aureus* (Mercier et al. 2020; Recuenco et al. 2020). Nonetheless, additional investigations on the antimicrobial potential of pili are needed. Possible antiviral and antifungal activities could also be explored as such properties had already been reported in other *Canarium* L. species (Mogana and Wiart 2011).

Other bioactivities. In vivo study on the immunomodulatory properties of *C. ovatum* Engl. ethanolic pulp extract has been carried out by Salvador-Membreve et al. (2018). In their study, both the 300 mg/kg and 600 mg/kg concentrations of the extract elicited a significant increase in footpad thickness (percentage edema index) and antibody titers at $p < 0.05$. Microscopic observations of the male Balb/C mice's spleen showed the presence of active germinal centers and proliferating lymphocytes, indicating the stimulatory effects of the ethanolic extracts during cellular and humoral immune responses.

In contrast, the anti-melanogenic activity of the pili resin has been reported by Kikuchi et al. (2012). Among the 18 terpenoids they isolated from the methanolic extracts of the resin, three sesquiterpene alcohols, namely, cryptomeridiol, 4-epicryptomeridiol, and cadin-1(14)-ene-7á,11-diol, had a remarkable inhibition of melanogenesis with no or low cytotoxicity at 100 ìM. Other terpenes such as á-amyrin, 3-epibrein, 3-epi-â-amyrin, and maniladiol also had anti-melanogenic effects with no or low cytotoxicity at lower concentration (10 ìM). This data suggests the potential of these compounds as skin-whitening agents.

Research and Development Opportunities

Pili is one of the flagship commodities of the Philippines, which remains its sole producer for commercial exploitation worldwide, with the Bicol Region as the major contributor to its production (Gallegos et al. 2013; Baleza 2020). It is the second economically important nut-producing tree crop in the country next to cashew (PSA 2018).

On average, the production of pili was estimated at 7.4 thousand metric tons per year, with a production value of 6.6 thousand metric tons in 2010 and 7.1 thousand metric tons in 2019. However, the highest production value of pili was recorded at 8.2 thousand metric tons in 2013, and since then, its supply has markedly decreased (PSA [date unknown]). As of 2019, the farm gate price of pili with the hull is PhP 18.09/kg, while depulped pili is sold at PhP 53.88/kg (PSA 2020). Processing the discarded pulp into oil offers additional income of PhP 599/kg, a cheaper alternative to imported oils such as olive oil (Catelo and Jimenez 2016). Furthermore, the average volume of exported pili from 2010-2019 is 35 metric tons, with the highest export noted in 2017 at 124 metric tons and the lowest in 2010 at less than 1 metric ton. Importation of pili has only been recorded in 2011 and 2017 at 1 and 27 metric tons, respectively (PSA [date unknown]). The major markets of exported pili are USA, UK, Ireland, and Canada (PSA 2020).

Because of its economic relevance, various efforts have been exerted to support the development of a pili industry. The Pili Research and Development (R&D) Center, a project under the Niche Centers in the Regions for R&D (NICER) Program of the Department of Science and Technology (DOST) Science for Change Program, was spearheaded by the Bicol University (BU), in cooperation with Central Bicol State University of Agriculture (CBSUA) and Partido State University (PSU) to improve and strengthen the pili nut industry in the Bicol Region. It includes seven projects that ultimately aim to provide Science and Technology (S&T)-based interventions to the industry by developing enhanced production and post-harvest technologies that would increase the yield and overall production of pili nut in the country. Such program is immensely significant to various stakeholders involved in planting and breeding pili as well as in conducting research and development activities and crafting policies related to the management and conservation of pili (Villegas and Sabanal 2019; Moral 2021).

Another initiative to support the growing pili industry is the Sorsogon Pili Enterprise – an enterprise development (I-REAP) subproject funded by the Department of Agriculture Philippine Rural Development Project (DA-PRDP) and implemented by three cooperatives in Sorsogon. This pili enterprise supports the province's Pili Roadmap and aims to expand the production and strengthen the market of their pili products (Baleza 2017, 2021). Few legislators have also sponsored a bill that aims to create a Pili Industry Development Program that will assist the Bicol Region in developing a pili industry through the continued support from the government (Lawmaker…2020). Other localities cultivating pili have also been tapped to boost the country's pili supply and meet the growing global demand (Meniano 2018).

However, despite these efforts, pili, together with other *Canarium* L. species, remains underutilized and understudied (Mogana and Wiart 2011; Rashid et al. 2021). Further investigations on histology, cellular and molecular biology, and ecology of pili should be performed in order to better understand its biology. These could be useful in developing breeding interventions and selecting superior varieties for commercial propagation. Genomic data of the genus *Canarium* L. is scarce; hence, determining the whole-genome sequence of pili as well as its organellar DNA could give better clues on its evolution and genetic diversity. Additional studies should also be performed to determine the other pharmacological activities of pili such as antiviral, antifungal, antiprotozoal, anti-inflammatory, and hepatoprotective. Further screening, isolation, and characterization of phytochemicals from various parts of the fruit and tree could be explored as this plant species had previously been described as a rich source of nutrients and bioactive compounds. In vivo and clinical applications of the previously isolated compounds from pili should be carried out to determine the extent of its observed bioactivities.

Moreover, mechanization of the processing of pili should continuously be promoted as it could shorten the production time and increase the yield, potentially meeting the global demand for pili products. Constant support from the government is very much needed to sustain the production of pili goods for both local and international markets. Ultimately, enough funding for research and development activities on pili, and in science and technology in general, should be given for continued efforts on discovering novel information about the plant itself which could be helpful in its cultivation, commercialization, and conservation. A new and efficient propagation method, which could serve as an alternative or a supplement to its existing macropropagation practices, is needed for its germplasm conservation and commercialization, such as in vitro propagation of pili should be explored.

Conclusion

Canarium ovatum Engl. is the next wonder tree in the country due to its various applications in agriculture, food industry, human health, and medicine. Its fruit contains edible parts that are highly nutritious and can be manufactured into different commercial and industrial products. The pili tree itself also serves as an excellent landscaping tree and windbreak for other crops.

Moreover, the plant has several ethnobotanical uses that are practiced in some localities around the country. Its fruit, leaves, and resin also have a diversity of compounds like alkaloids, flavonoids, tannins, terpenoids, glycosides, and sterols that have pharmacological activities. Other phytonutrients such as fatty acids, amino acids, carbohydrates, dietary fibers, vitamins, and minerals are also abundant in pili, making it safe for human consumption. Likewise, various extracts and oils derived from its fruit, leaves, bark, and resin possess bioactivities such as antioxidant, anticancer, antibacterial, anti-melanogenic, and immunostimulatory.

Given the usability of almost all parts of pili, it has been regarded as one of the most economically important crops in the country that needs thorough research and development activities. Additional studies on its histology, molecular biology, genetics, and ecology could shed further light on its biology and evolution, which are very important for its commercial cultivation and conservation. Constant government support through sound and effective policies, as well as research funding, is also needed to strengthen and sustain its growing industry.

Jessica D. Rey *received her BS Biology degree major in Cell Biology, Master of Science degree in Genetics with minor cognate in Microbiology and PhD in Genetics with Plant Pathology as her minor cognate from the University of the Philippines (UP), Los Banos and the International Rice Research Institute (IRRI). She also earned 12 units of Biostatistics from the University of Washington, Seattle.*

Currently, she is an assistant professor at the Institute of Biology, College of Science, University of the Philippines, Diliman, teaching plant developmental biology and genetics. She heads the Plant Molecular Phylogenetics Laboratory, led the DOST SPICE project and now leads a research on strawberry and Pili. She serves as a member of Technical Panel for DA Biotech and the editorial board of Philippine Journal of Crop Science and Philippine Journal for Arts, Science and technology.

Cedrick V. Alguzar *is a University Research Associate I at the Institute of Biology, University of the Philippines Diliman, where he is also completing his Master's Degree in Biology (Plant Developmental Biology). Prior to this, he was a Senior High School Teacher at the Ateneo de Naga University, where he taught General Biology courses to STEM students. He also obtained his Bachelor's Degree in Secondary Education (Biology-Chemistry) from the same institute and graduated Magna Cum Laude with Academic Distinction. His research interests include developmental biology and host infection of Rafflesia, and plant tissue culture.*

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