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Review article

Indigenous Knowledge of Medicinal Fruits in the Philippines: a Systematic Review

Resti Tito Villarino[1,2*], Maureen Lorence Villarino[2,3]

[1]Local Research Ethics Committee, Cebu Technological University, Moalboal, Cebu, Philippines.
[2]Medical Sciences Division, National Research Council of the Philippines, Manila, Philippines.
[3]College of Nursing, West Visayas State University, Iloilo City, Philippines.

Abstract

Medicinal fruits as adjunct therapy are promising for acute and chronic diseases. However, the role of these fruits remains largely unexplored. This study reviewed the evidence-based efficacy of these fruits used by indigenous people in the Philippines. Indigenous knowledge on using medicinal fruits was searched in the Philippine Traditional Knowledge Digital Health Library database. Medical research databases [Medline, Scopus, GreenFILE, ProQuest, HERDIN, and JSTOR] were queried from inception to April 2022. Searches were in English and Filipino language publications. A narrative synthesis was conducted and 30 articles from the Philippine Traditional Knowledge Digital Health Library database identified the medicinal fruits used among indigenous people in the Philippines. Moreover, 40 articles that included 17 experimental research, 20 reviews, and 3 published reports pointed to the evidence-based effectiveness of these fruits. According to this review, the medicinal fruits included were scientifically evaluated for their medicinal properties, including their anti-oxidant and phytochemical attributes. However, the scientific evidence from previous literature indicated that most experiments constituted in vitro and animal models. Traditional medicine and scientific evidence revealed the protective effects of these fruits against various ailments. Since there were not many human intervention trials available, researchers can study the potential health effects of these therapeutic fruits by using human models in the future. Due to the various health benefits of these indigenous fruits, it is essential to explore their disease-fighting capabilities and convert them into nutraceuticals or functional food ingredients.

Keywords: ethnobotany; indigenous knowledge systems; nutraceuticals; Philippines; prevention of disease

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Introduction

Plant species are abundant in the Philippines, including more than a thousand varieties of fruit-bearing trees. Several of these fruits have previously been introduced to the marketplace, but most remain unused [1,2]. These fruit trees are perennial sources of food for humans and animals. In antiquity, cultivating fruit-bearing trees for their edible fruits was limited to growing them near or on the home's property.

Since the birth of civilization, several fruits have been utilized as home medicines. The leaves, fruits, bark, stems, roots, branches, and sap are used worldwide in traditional medicine [3–5]. Indigenous people have used these parts as folk medicines to treat various conditions, including cough, fever, asthma, diarrhea, indigestion, and skin diseases [2]. In modern medicine, extracts from various parts of plants, including fruits, are

*Corresponding author: restitito.villarino@ctu.edu.ph

used for their medicinal benefits as agents that combat fungi, microbes, atherosclerosis, high cholesterol, leukemia, proliferation, and clastogenesis [1]. The majority of bioactive compounds found in plant extracts are candidates for their medicinal properties [6,7].

Phytochemicals and other compounds are abundant in edible fruits. According to the studies [8,9] most fruits are rich in phytochemicals, mainly phenolic compounds, carotenoids, terpenes, and other terpenoids. Moreover, these phytochemicals protect against chronic diseases such as cardiovascular disease, diabetes, and cancer [10,11]. Phytochemicals are also responsible for fruits' anti-inflammatory, antibacterial, and therapeutic activities [6,12].

Terpenoids are a diverse class of naturally occurring chemical substances [2] in fruits. Most terpenoids, including saponins, may possess antioxidative effects [13]. Saponins have various health benefits [12] and anti-oxidant properties. Some terpenes and terpenoids are volatile plant-based chemicals. Terpenes, especially sesquiterpenes, have been identified in plant roots, bark, flowers, and leaves [5]. Although various studies on volatile terpenes in plant essential oils have been undertaken, most have focused on plant components other than the fruit.

Carotenoids are terpenoids. These chemicals are prevalent in fruits with hues ranging from yellow to orange to red. Carotenoids are composed of groups of carotene and xanthophyll. ß-Carotene is the most common form of natural carotene, but lycopene is the most prevalent phytochemical in orange-red fruits. Lutein, a xanthophyll, is commonly present in green, leafy plants [14].

Across the plant kingdom, phenolic compounds, the biggest group of phytochemicals, are extensively spread. As fruits' most abundant bioactive components, phenols have a significant anti-oxidant effect. The fruit pulps include antioxidant-rich phenolic components, such as phenolic acids and flavonoids, whereas the fruit seeds and kernels contain flavonoids and lignans [15]. Gallic acid is the most prevalent phenolic acid in plants. Each fruit includes at least five phenolic chemicals of significance. In addition, catechin is one of the most prevalent flavonoids in leaves. Since phenolics are potent anti-oxidants, increasing one's regular fruit consumption should supply adequate phenolic anti-oxidants [10].

The identification and abundance of bioactive chemicals in fruits encourage the consumption of these underutilized foods for their health benefits. In addition, identifying medicinal fruits with the potential for nutraceuticals or functional foods will help researchers, farmers, and the industry recognize the prospects given by these indigenous fruits. Thus, this review aims to synthesize the evidence-based efficacy of indigenous Filipino medicinal fruits.

Methods

The methods used to collect and summarize the data adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses standards [16,17]. Moreover, the authors took photos of the medicinal fruits presented in the subsequent section.

Inclusion criteria

Studies were included in the review if they met the following criteria: a) they referred to medicinal fruits endemic to the Philippines; b) they included indigenous people (IP) in the Philippines; c) they examined the effects of medicinal fruits on human diseases (including - but not limited to hypertension, diabetes mellitus, cancer, arthritis, and obesity); d) they were original research articles, reviews, or reports that described data on the utilization of these medicinal fruits; e) they constituted peer-reviewed literature (including thesis and dissertations) published in English (languages in which all authors are fluent).

Exclusion criteria

Studies were excluded from the systematic review if they did not meet the above-cited inclusion criteria or pertained to the medicinal use of flowers and fauna.

Information sources

The Philippine Traditional Knowledge Digital Health Library database was queried for information on the utilization of therapeutic fruits. From inception through April 2022, the databases (Medline, Scopus, GreenFILE, Proquest, HERDIN, and JSTOR) were examined for evidence of the usefulness of these fruits. Searches were in English and Filipino language publications.

Data analysis

A narrative synthesis [18] was carried out to

synthesize the findings from included studies. The method was preferred to accommodate the analysis of a wide range of study designs. The authors conducted a preliminary synthesis in the form of analysis [19]. Results were then discussed and structured into the medicinal fruits used by indigenous people in the Philippines. The diversity in reviewed study designs was precluded by performing a quality assessment of the included articles.

Results and Discussion

As presented in Figure 1, thirty articles from the Philippine Traditional Knowledge Digital Health Library database identified the medicinal fruits used among indigenous people in the Philippines. Medical research databases identified 400 references; 27 were duplicates and thus removed. After reviewing titles and abstracts, 333 references were excluded because they did not meet the inclusion criteria: a) not endemic in the Philippines, b) not indigenous people from the Philippines, c) flowers, and d) fauna. As a result, this review included 40 academic articles with 17 experimental research [3,9–12,20–31], 20 reviews [4,6,8,23,32–47], and 3 published reports [48–50]. The identified articles were published in journals devoted to various academic disciplines, including food research, complementary medicine, indigenous knowledge, and environmental research.

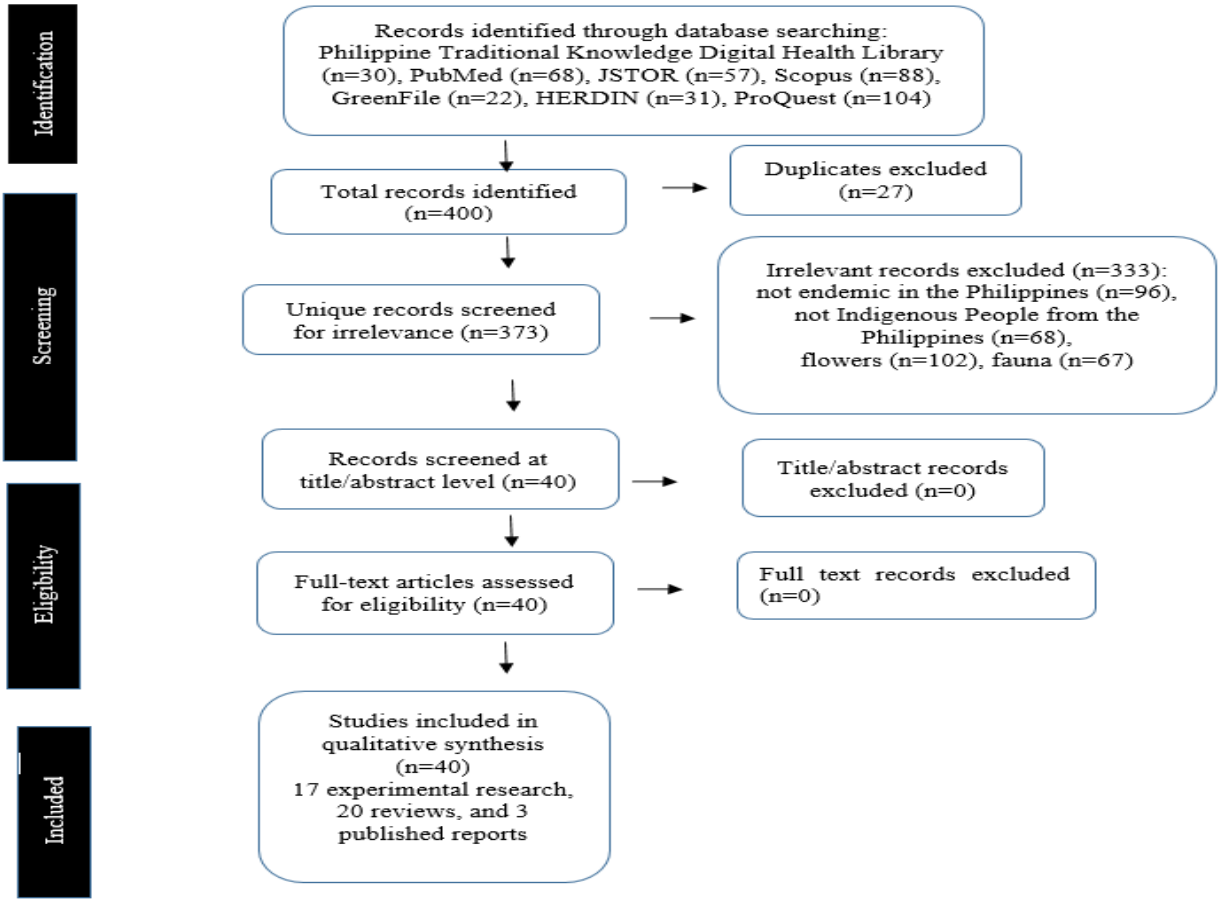

Figure 1. Study selection flowchart

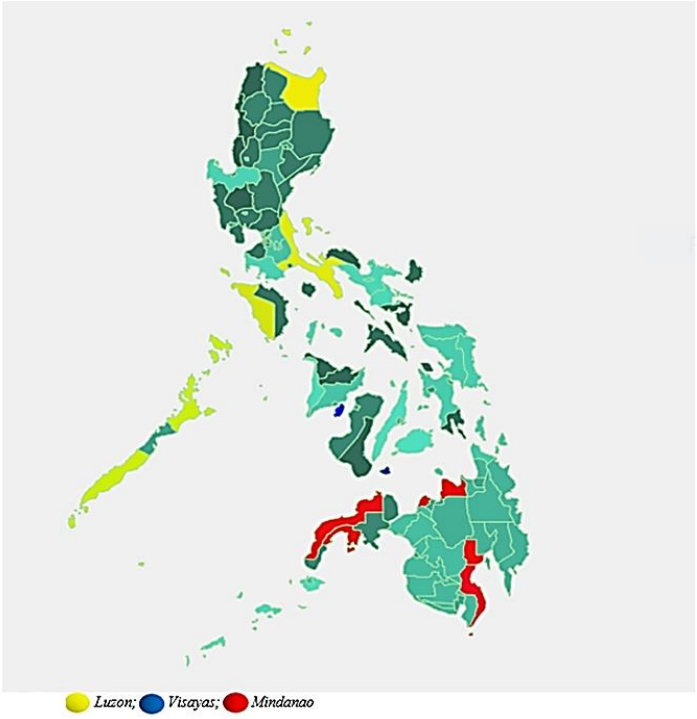

Figure 2. Geographical location of the indigenous people in the Philippines

Seventeen indigenous groups who utilized the medicinal fruits in this review were identified (Figure 2). These were the Ayta, Mangyan, Bagobo, Ati, Ata-Manobo, Kalanguya, Dibabaon, Dumagat, Batan, Sumadel- Kalinga, Palawan people, Kankana-ey, Siquijor people, Isnag, Subanen, Mandaya, and Bugkalot. Eleven tribes (Ayta, Mangyan, Kalanguya, Dibabaon, Dumagat, Batan, Sumadel-Kalinga, Palawan people, Kankana-ey, Isnag, and Bugkalot) came from Luzon provinces; two from the Visayas (Ati and Siquijor people); and four from Mindanao (Bagobo, Ata-Manobo, Subanen, and Mandaya).
The results were presented in sections on the 10 medicinal fruits used by the indigenous people in the Philippines. The traditional use, recent investigations, and research design are presented in Table 1.

Annona squamosa L.

A tiny and densely branching tree or shrub in the family Annonaceae, between 3 and 8 meters (10 to 26 feet), *Annona squamosa* (Figure 3) produces edible fruits [51]. It is the most widely cultivated of the Annonaceae species because it can withstand tropical lowland climates better than its relatives, *Annona reticulata* and *Annona cherimola* [12]. The parts used as medicine were leaves, seeds, and fruit [52,53]. *Annona squamosa* has substantial benefits as a natural fruit ingredient, nutritional food component, and natural medicinal plant [12]. It has also boosted cellular proliferation in Human Dermal Fibroblasts (HDF) culture and displayed antibacterial efficacy against numerous pathogenic strains [26]. The leaf extract of *Annona Squamosa* has a potential pediculicidal activity [25].

Figure 3. *Annona squamosa* L.

Artocarpus heterophyllus Lam.

The jackfruit (*Artocarpus heterophyllus*) (Figure

4) is a type of tree belonging to the Moraceae family, including the fig, mulberry, and breadfruit [40]. Its native range is between the Western Ghats in southern India, Bangladesh, Sri Lanka, and the rain forests of the Philippines, Indonesia, and Malaysia [46]. The fruits, leaves, and barks of *A. heterophyllus* were used as medicine among the indigenous people in the Philippines [53,54]. Jackfruit contains carbohydrates, proteins, vitamins, minerals, and phytonutrients [42]. Traditional medicine has made considerable use of jackfruit fruits, leaves, and barks due to their anticarcinogenic, antibacterial, antifungal, anti-inflammatory, wound-healing, and hypoglycemic effects [46]. Jackfruit can protect against and even improve a variety of ailments, including stomach ulcers and cardiovascular disease [44].

Figure 4. *Artocarpus heterophyllus* Lam.

Chrysophyllum cainito L.

The tropical tree *Chrysophyllum cainito*, known as star apple (Figure 5), belongs to the Sapotaceae family [36]. It grows quickly and can reach a height of 20 meters.

Table 1. Medicinal fruits endemic to Philippines

Medicinal fruit	Traditional use	Recent investigations	Research design
Annona squamosa L. English name: Custard apple Local name: "Atis"	Cough, fever, diarrhea [52,53,55]	Antibacterial, anti-oxidant, and pediculicidal properties [12,15,51,56]	In vivo and in vitro experiments
Artocarpus heterophyllus Lam. English name: Jackfruit Local name: "Nangka"/"Langka"	Wound, anti-helminthic [53,54,57]	Phytonutrient, anticarcinogenic, anti-inflammatory, antifungal, and antidiabetic properties [40,42,44,46]	In vitro experiments and reviews
Chrysophyllum cainito L. English name: Star apple Local name: "Caimito"	Inflammation, diarrhea, and venereal diseases [58–60]	Anti-oxidant, antidiabetic, and anti-inflammatory properties [3,11,24,36]	In vivo and in vitro experiments
Syzygium cumini L. English name: Black plum/ Jambolan Local name: "Duhat"/"Lomboy"	Diarrhea, improve sexual stamina [32,61,62]	Antihypertensive, antidiabetcic properties [1,6,10,27]	In vivo, in vitro experiments, reports
Carica papaya Linn. English name: Papaya Local name: "Kapayas"	Rheumatism, as digestive and tonic, used to cure dyspepsia [52,63,64]	Antiviral, antifungal, and antibacterial properties [32,66,68,69]	In vivo and in vitro experiments
Tamarindus indica L. English name: Tamarind Local name: "Sampalok"/"Sambag"	Abdominal pain, diarrhea, and helminths infections [63,65,66]	Anti-cancer, anti-inflammatory, antihypertensive, antidiabetic properties [34,39,41,50]	In vitro experiments and reviews
Manilkara Zapota L. English name: Sapodilla Local Name: "Chico"	Cough, cold, inflammation [57,58,67]	Antilipidemic, antidiabetic, antihypertensive, anti-oxidant properties [1,23,31,68]	In vivo, in vitro experiments, reports
Persea americana L. English name: Avocado Local name: "Abokado"	Gum disease, diarrhea, and sore throat gum disease, diarrhea, and sore throat [65,69,70]	Antihypertensive, antilipidemic properties [37,38,48,49]	In vivo, in vitro experiments
Averrhoa bilimbi L. English name: Cucumber tree Local name: "Kamias"/"Iba"	Fever and cough [52,71,72]	Anti-oxidant and antibacterial properties [8,20–22]	In vitro experiments and reviews
Sandoricum koetjape Merr. English name: Cotton fruit Local name: "Santol"	Fever and digestive issues [72–74]	Anti-inflammatory, anti-cancer, and anti-angiogenic properties [4,28,30,75]	In vivo and in vitro experiments

It was domesticated on the Isthmus of Panama, where it is originally from [11]. Since then, it has spread to the Greater Antilles and the West Indies and grown all over the tropics, including Southeast Asia [24]. The parts utilized were the leaves and fruit of *C. cainito* [58,60]. The pharmacological characteristics of *C. cainito* include anti-oxidant, antidiabetic, and anti-inflammatory properties [11]. The pulp coat of the star apple had the highest quality compared to other parts of the fruit [24]. *Chrysophyllum cainito* can potentially be a management for preventing and treating type 2 diabetes [3].

Figure 5. *Chrysophyllum cainito* L.

Syzygium cumini L.

Syzygium cumini (Malabar plum or jambolan] (Figure 6) is an evergreen tropical tree in the flowering plant family Myrtaceae native to the Indian subcontinent and neighboring Southeast Asian countries like Myanmar, Sri Lanka, and the Andaman Islands [6]. It can grow as tall as 30 meters [98 feet] and live for more than 100 years [10]. Indigenous people used fruit, bark, and leaves as medicine [32,61]. *Syzygium cumini* seeds contain the alkaloid jambosine and glycosides jambolin or antimellin, which block the diastatic conversion of starch to sugar [32]. *Syzygium cumini* decreases systolic blood pressure and heart rate, probably due to the reduction of arterial tone and extracellular calcium influx [27].

Carica papaya Linn.

Carica papaya Linn. (Family: Caricaceae), often referred to as papaya (Figure 7), is a fruit indigenous to Southern Mexico, Central America, and Northern South America [45]. Papaya is grown throughout most tropical nations, including Malaysia, the West Indies, and Africa [45].

Figure 6. *Syzygium cumini* L.

The fruit, leaves, seed, root, bark, juice, and latex of *C. papaya* have been used [64,76]. Papaya has antiviral, antifungal, and antibacterial properties due to its high vitamin A, B, and C content and proteolytic enzymes such as papain and chymopapain [45]. It treats various ailments, including dengue fever, warts, skin inflammation, diabetes, glandular tumors, high blood pressure, digestive disorders, and constipation [33].

Figure 7. *Carica papaya* Linn.

Tamarindus indica L.

Leguminous tamarind trees (*Tamarindus indica*), which produce edible fruits, are most likely native to tropical Africa [34]. Tamarind (Figure 8) is a monotypic genus, which means that just one species belongs to it and is a member of the Fabaceae family [41]. A sweet, sour pulp found in the brown, pod-like fruits that the tamarind tree produces is utilized in foods and is grown worldwide in tropical and subtropical regions because it has many uses as food and medicine [39]. The Indigenous people used the fruit, leaves, and bark of *T. indica* [65,66]. *Tamarindus indica* positively affects various health disorders and life-threatening conditions such as cancer, cardiovascular disease, arthritis, diabetes, epilepsy, nonalcoholic fatty liver, and

inflammatory bowel disease [39]. The tamarind pulp is a rich source of potassium, which regulates heart rate and blood pressure [50].

Figure 8. *Tamarindus indica* L.

***Manilkara zapota* L.**

Manilkara zapota, or sapodilla (Figure 9), is a long-lived, evergreen tree indigenous to southern Mexico, Central America, and the Caribbean [23]. It is a subdominant plant species in the Petenes mangrove ecoregion along the coast of Yucatán, as an example of a natural occurrence [68]. It was brought to the Philippines during Spanish colonialism and is widely grown in tropical Asia, including India, Pakistan, Thailand, Malaysia, Cambodia, Indonesia, Vietnam, Bangladesh, and Mexico [23]. The fruit and leaves of *M. zapota* were used as medicine [67,77]. After consuming sapodilla, a significant decrease in cholesterol and increased glucose was observed, but no significant cytokine changes [68]. Sapodilla pulp and peel can be utilized as natural anti-oxidant sources in the food industry [23]. Tannin-rich *M. zapota* is an excellent source of vitamin C, iron, and fiber [43].

***Persea americana* L.**

The medium-sized, evergreen avocado tree (*Persea Americana*) (Figure 10) is a member of the laurel family (Lauraceae) [48]. It was cultivated for the first time by Mesoamerican tribes more than 5,000 years ago and is indigenous to the Americas [38]. The avocado tree probably originated in the highlands spanning south-central Mexico and Guatemala and was prized both then and now for its large and unusually oily fruit [37].

Moreover, *P. americana* contains a single large seed, is partially self-pollinating, and frequently propagates through grafting to maintain consistent fruit output [49].

Figure 9. *Manilkara zapota* L.

The parts used were leaves, fruit, and seed [69,70]. The average avocado intake is one-half fruit, which provides significant amounts of the following nutrients and phytochemicals: fiber, potassium, magnesium, vitamin A, vitamin C, vitamin E, folate, vitamin B-6, niacin, pantothenic acid, choline, lutein/zeaxanthin, phytosterols, and monounsaturated fatty acids(MUFA] rich oil [37]. The sugar level of avocados is relatively low, with only about 0.2 grams per half-fruit [38]. Studies have proved the health benefits of including avocado in a balanced diet, mainly decreasing cholesterol and preventing cardiovascular disease [48].

Figure 10. *Persea americana* L.

***Averrhoa bilimbi* L.**

Averrhoa bilimbi (Figure 11) is a fruit-bearing tree belonging to the family of Oxalidaceae [8]. *Averrhoa bilimbi* is a little tropical tree that can grow up to 15 meters tall and is native to Malaysia and Indonesia and is frequently multi-trunked and soon divides into branches [22]. The leaves are alternating, pinnate, and range in length from 30 to 60 cm and each leaf has 11–37 leaflets that are elliptical to oblong, 2–10 cm long, and 1-2 cm wide, and they cluster at the ends of the branches [21]. The leaves and fruits of the tree have panicles that grow on the trunk and other branches that contain 18–68 blooms,

making it cauliflorous. The fruits and leaves were used as medicine [52,71]. The leaf powder of *A. bilimbi* contained the highest percentage of carbohydrates, and the mineral analysis revealed that potassium was the most prevalent element in powdered leaves [21]. Moreover, the leaves also have anti-oxidant and antibacterial activities [8]. The isolation of antibacterial and cytotoxic substances from the leaves could be beneficial for developing novel medications [20].

Figure 11. *Averrhoa bilimbi* L.

Sandoricum koetjape Merr.

The cotton fruit (Figure 12) is a tropical fruit indigenous to maritime Southeast Asia [4]. Although imported to Indochina, Sri Lanka, India, northern Australia, Mauritius, and Seychelles, it is a native of the Malesian floristic region [28]. It is widely grown in these areas, and the local and global markets are stocked with abundant fruits according to the season [75]. The Indigenous people use the fruit, roots, and leaves of *S. koetjape* [73,74]. The cotton fruit also contains anti-inflammatory triterpenes, such as sentulic acid and koetjapic acid [4]. This tetracyclic triterpenoid exhibits anti-cancer, anti-metastasis, and anti-angiogenic activities [28]. The cotton fruit polysaccharide demonstrated its capacity to specifically support the growth of *Lactobacillus acidophilus*, making it a potential probiotic dietary additive [30].

The research regarding the therapeutic effects of fruit consumption is consistent with our findings. In biological science, it is given that mammalian and plant cells are continuously exposed to oxidizing substances. These oxidizing agents can be found in air, food, and water, or cells' metabolic activity can produce them. However, maintaining optimal physiological circumstances requires a balance between oxidants and anti-oxidants.

Figure 12. *Sandoricum koetjape* Merr.

Overproduction of oxidants can lead to an imbalance and oxidative stress [78]. Oxidative stress can cause oxidative damage to macromolecules such as lipids, proteins, and DNA, increasing the risk of chronic diseases such as cancer and cardiovascular disease [79]. To avoid or lessen the oxidative stress caused by free radicals, it is necessary to consume adequate anti-oxidants, most of which originate from fruits [80]. Moreover, previous studies [1,81] revealed that consuming fruits protects against coronary heart disease and stroke. In connection to these studies, it was also established that individuals who consumed approximately more than 5 servings of fruits per day had a 20 percent lower risk of heart disease than those who consumed fewer than 3 servings.

Aside from the protective effects of fruits in coronary heart disease and stroke prevention, it was also found that consuming fruits may protect from osteoporosis due to their calcium and vitamin content, which is needed for bone health [24,82]. Fruits' high fiber content may play a role in calcium absorption and reduce the "acid load" of the diet, stimulating bone formation and decreasing bone resorption, resulting in stronger bones [78,82].

Despite these potential health benefits, additional controlled clinical intervention trials are required to confirm findings that support the notion that fruit consumption improves health and reduces the risk of developing chronic diseases. Due to several factors, including their international variety, diverse eating patterns, and interactions with other nutritional components [78], accurate measurement of dietary consumption remains challenging.

Although research evidence supports the association between fruit consumption and decreased incidence and mortality of chronic

diseases such as obesity, various cancers, and cardiovascular diseases [1,9,83,84], the scientific community is still inconclusive regarding their association; thus, large-scale, long-term studies are recommended.

Conclusion

Traditional medicine and scientific evidence both suggest that the fruits used by indigenous people in the Philippines have protective effects against various ailments. These fruits have been studied for their therapeutic characteristics, but the scientific data is limited, and the studies are still in their early stages. In the future, researchers can investigate the potential health impacts of these therapeutic fruits using human models, as few human intervention trials are available. Given these fruits' numerous health benefits and bioactive phytochemicals, exploring their disease-fighting capabilities and transforming them into nutraceuticals or functional food ingredients is crucial.

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Author contributions

Resti Tito Villarino and Maureen Lorence Villarino contributed to conceptualization, data curation, investigation, and drafted the manuscript. All the authors have approved the final draft of the manuscript.

Declaration of interest

The authors declare that there is no conflict of interest. The authors alone are responsible for the accuracy and integrity of the paper's content.

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Abbreviations

HDF: human dermal fibroblasts; HERDIN: health research and development Information Network; JSTOR: journal storage; MUFA: monounsaturated fatty acids