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Herbal Therapy Potential of Balinese Local Plants for Degenerative Diseases: A Review

Ida Ayu Manik Damayanti

Bachelor of Clinic and Community Pharmacy Program, Faculty of Health, Institute of Technology and Health Bali, Bali, Indonesia
*e-mail: idaayumanikk@gmail.com

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Abstract: Indonesia has a rich biodiversity, including numerous medicinal plants. However, their utilisation remains limited, particularly in treating degenerative diseases. This study explores the potential of local Balinese plants as herbal therapy for diabetes mellitus and hypertension through a systematic literature review. Data were collected from scientific databases such as PubMed, Google Scholar, and Science Direct, covering publications from 2018 to 2025. Out of 117 identified articles with exclusion and the same article, 13 relevant studies were selected as primary references. The analysis indicates that plant extracts from *Murraya paniculata, Vitis vinifera* Var. Alphonso Lavallee, *Syzygium polycephalum*, *Antidesma bunius*, *Aegle marmelos*, *Zingiber zerumbet*, *Elaeocarpus grandiflora*, *Artocarpus altilis*, *Impatiens balsamina*, *Tagetes erecta*, *Vitex trifolia*, and *Punica granatum* show potential in managing degenerative diseases. Their bioactive compounds, including flavonoids, phenolics, tannins, terpenoids, alkaloids, and saponins, act by inhibiting key enzymes, enhancing insulin sensitivity, reducing oxidative stress, and modulating lipid metabolism. These findings suggest that Balinese local plants have promising potential as natural therapies for degenerative diseases, warranting further clinical validation.

Keywords: Balinese Local Plants; Degenerative Disease; Herbal Therapy.

Introduction

Indonesia is known as a country with abundant biodiversity, having around 30,000 plant species, of which more than 9,600 are known to have medicinal properties. However, the utilization of these medicinal plants has not been optimal, with only around 200 species used as raw materials for the traditional medicine industry. This shows the huge untapped potential in the development of local plant-based medicines. Traditional utilization of medicinal plants has been an integral part of Indonesian culture, passed down from generation to generation and used to treat various diseases. However, modernization and lack of scientific research have overlooked this traditional knowledge. Therefore, efforts are needed to document and further research the potential of Indonesian medicinal plants. As part of Indonesia, Bali has a unique wealth of flora and potential as a source of herbal medicine. Several local Balinese plants, such as Kemoning (*Murraya paniculata* Jacq.), Lempuyang Wangi (*Zingiber zerumbet*), Buni (*Antidesma bunius* Spreng.), and many more are known to have both therapeutic and medicinal properties [1].

Degenerative diseases, such as diabetes mellitus, hypertension, and coronary heart disease, are major health problems in Indonesia. Data from the Indonesian Health Survey [2] shows that the prevalence of non-communicable diseases, including degenerative diseases, has increased significantly in recent years. The prevalence of diabetes mellitus in the population over 15 years increased from 6,9% in 2018 to 8,5% in 2023. Similarly, hypertension showed an increase from 34,1% to 36,9% over the same period. The increasing burden of these diseases underscores the urgent need for effective prevention and treatment strategies. Lifestyle changes and unhealthy dietary habits are primary contributors to this rising trend. Although conventional treatments exist, they are often costly and associated with adverse side effects, leading many to seek natural alternatives. Medicinal plants, rich in bioactive compounds such as flavonoids, phenolics, tannins, and alkaloids, offer promising therapeutic potential by modulating oxidative stress, inflammation, and metabolic pathways.

In addition to therapeutic applications, the sustainable cultivation of medicinal plants is vital for ensuring their long-term availability. Effective cultivation techniques enhance the quality and quantity of herbal raw materials and contribute to environmental conservation. Evaluating the habitat conditions and optimizing the cultivation of medicinal plants are essential steps in their development. Given Indonesia's favourable climate and soil conditions, the prospects for medicinal plant cultivation are promising. Moreover, the growing demand for herbal medicine presents opportunities to expand the traditional medicine industry. With appropriate research, development, and cultivation strategies, medicinal plants could emerge as leading commodities supporting sustainable agriculture and public health. Additionally, integrating modern biotechnological approaches, such as metabolomics, molecular docking, and in vivo studies, could help unravel these plants' precise mechanisms of action in preventing and treating degenerative diseases. This research aims to bridge traditional knowledge with modern science by addressing these gaps and developing safe, effective, evidence-based herbal medicines.

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Research Methods

This review employs a systematic literature review approach following PRISMA guidelines. Relevant articles were collected from databases such as Google Scholar, PubMed, ScienceDirect, and NCBI using keywords like *Balinese medicinal plants*, *herbal therapy*, and *degenerative diseases*, focusing on publications from 2018–2025. The selection, guided by the PICO framework, included peer-reviewed studies on Balinese plants with therapeutic potential, phytochemical composition, and efficacy against degenerative diseases while excluding reviews, non-Balinese plants, and insufficiently detailed studies. Data extraction focused on bioactive compounds, mechanisms of action, and therapeutic applications, analysed through narrative synthesis due to methodological variability. This review aims to provide insights into the therapeutic potential of local Balinese plants in degenerative disease management, contributing to the development of evidence-based herbal treatments and encouraging further pharmacological research.

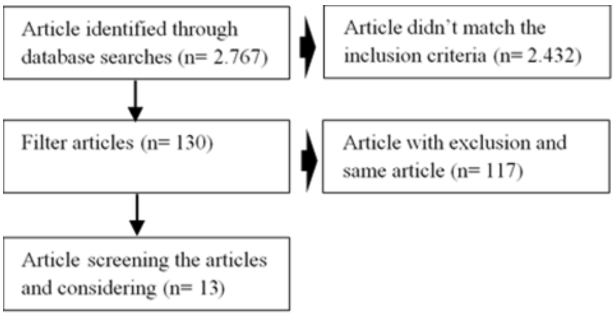

Figure 1. Article search flow process

Table 1. PICO Framework

Population (P)	Balinese local plants have potential herbal therapy effects for degenerative diseases.
Intervention (I)	Extraction and utilization of bioactive compounds from these plants for treating degenerative diseases.
Comparison (C)	Comparison between various plant extracts regarding phytochemical content, antioxidant activity, and therapeutic efficacy.
Outcome (O)	Evaluation of phytochemical composition, antioxidant capacity, and effectiveness in managing degenerative diseases.

Results and Discussion

Balinese local plants are listed in the Governor's Decree Number 29 of 2020 concerning the Preservation Of Bali Local Plants As Taman Gumi Banten (Complementary To Prayers), Puspa Dewata (Means Of Upakara And Prayers), Usada (Traditional Health), And Reforestation [1]. Several herbal plants that grow in Bali have the potential as herbal therapy for degenerative diseases. These plants contain various active compounds with various pharmacological activities, such as antioxidants, anti-inflammatories, and neuroprotective, which play a role in preventing or inhibiting the development of degenerative diseases. The effectiveness of herbal therapy is assessed based on its bioactive content and its mechanism of action in the body, which can contribute to protecting cells from damage due to oxidative stress and chronic inflammation. The presence of antioxidant compounds in these plants affects reducing cholesterol levels, blood glucose, and uric acid, which are associated with several degenerative diseases, such as hypercholesterolemia, atherosclerosis, and diabetes mellitus [3-5].

Table 2. Herbal Therapy Potential of Balinese Local Plants for Degenerative Diseases

Scientific Name	Balinese Local Name	Plant part used	Content of compounds	Value of Compound Content	Dose of Extract	Functions	How Compounds Work
Murraya paniculata Jacq. [6]	*Kemoning*	Stem bark	Tannin Flavonoid Phenol	Total Flavonoid 892,35 mg/100 g QE Total Phenol 2089,345 mg/100 g GAE Total Tannin 1876,87 mg/100 g GAE	69 gr/150 BW	Lower LDL	Inhibits HMG Co-A reductase enzyme to lower LDL
Murraya paniculata Jacq.[7]	*Kemoning*	Leaf	Tannin Flavonoid Alkaloid Steroid	Total flavonoid 100,95 ppm	200 mg/kg BW	Anti-obesity	Forms covalent bonds with serine residues on pancreatic lipase, thereby inhibiting fat absorption in the digestive tract

Zingiber zerumbet [8]	*Lempuyang Wangi*	Rhizome	Phenol Flavonoid	Total phenolic 53,18 mg GAE/g Total flavonoid 17,11 mg QE/g	75 mg/kg BW	Antidiabetic	Inhibits protein aldose reductase, has antioxidant and anti-inflammatory effects
Antidesma bunius Spreng. [9]	*Buni*	Fruit	Anthocyanins	IC50 DPPH 15,84 μg/mL	0.25 mg/mL	Formation of Advanced Glycation Products (AGEs) Prevention of type 2 diabetes	Inhibits α-amylase and α-glucosidase and reduces protein glycation
Aegle marmelos [10]	*Maja*	Leaf	Flavonoid Phenol Terpenoid	IC50 DPPH 42,07 ppm	250 mg/kg	Antidiabetic	Inhibits α-amylase and α-glucosidase enzymes, reduces oxidative stress in HepG2 cells
Artocarpus altilis [11]	*Sukun*	Leaf	Flavonoid	IC50 DPPH 86,305 μg/mL	500 mg	Antidiabetic	Improves insulin sensitivity and protects pancreatic cells from oxidative damage
Syzygium polycephalum Miq. [12]	*Kaliasem*	Fruit	Polyphenol Flavonoid	IC 50 DPPH 16,728 ppm	1000 mg/kg BW	Antidiabetic	Inhibits α-glucosidase enzyme
Elaeocarpus grandiflora J.E. Smith [13]	*Rijasa*	Flower	Quercetin Kaempferol Orientin Flavonoid	Total Kaempferol 242,9 mg/g Total Flavonoid 556,9 mg QE/g	100-400 mg/kg BW	Antidiabetic and Weight loss	Improves insulin sensitivity and reduces glucose absorption in the gut
Vitis vinifera L. Var. Alphonso Lavallee [14]	*Anggur Bali*	Fruit	Terpenoid Saponin Flavonoid Tannin Carotenoid	IC50 DPPH 53,95 ppm	400 mg/kg BW	Antihyperglycemic	Increases pancreatic beta cell
Impatiens balsamina L. [15]	*Pacah*	Flower	Alkaloid Terpenoid Saponin Phenolic Flavonoid	IC50 DPPH 40,71 ppm	400 mg/kg BW	Antihyperglycemic	Inhibition of lipid synthesis or increased lipid catabolism. Decreases malondialdehyde (MDA) levels and increases the activity of antioxidant enzymes such as SOD, GSH, and catalase
Tagetes erecta L. [16]	*Gemitir*	Flower	Alkaloid Flavonoid Saponin Tannin	IC50 DPPH 50,77 ppm	75 mg/kg BW	Antidiabetic and anti-obesity	Inhibits pancreatic α-glucosidase and lipase enzymes, lowering body fat
Vitex trifolia L.[17]	*Lagundi*	Leaf	Phenolic Flavonoid	Total phenolic 95,12 mg GAE/g Total flavonoid 42,50 mg QE/g	100 mg/mL	Antidiabetic	α-amylase inhibition

Punica granatum [18]	*Delima*	Fruit peel	Phenolic Flavonoid	Total phenolic 125,24 mg GAE/g Total flavonoid 57,96 mg QE/g	200 mg/kg BW	Atherosclerosis Progression	Enhanced macrophage efferocytosis efficiency, contributing to the resolution of inflammation in atherosclerosis

The above Balinese local plants extracted using the maceration method contain active compounds such as flavonoids, phenolics, tannins, terpenoids, and alkaloids, which have various health benefits. Most of these plants have antidiabetic activity through the mechanism of α-amylase and α-glucosidase enzyme inhibition, increased insulin sensitivity, and protection of pancreatic cells from oxidative stress. Some plants show additional activities besides antidiabetes. *Murraya paniculata* from the stem bark has LDL-lowering effects by inhibiting the enzyme HMG Co-A reductase. At the same time, its leaf extract serves as an anti-obesity agent by inhibiting pancreatic lipase. *Punica granatum* (pomegranate) was shown to be effective in slowing the progression of atherosclerosis by increasing macrophage efferocytosis, thus contributing to the resolution of inflammation.

The total phenol and flavonoid content varies among species. For example, *Murraya paniculata* has a total flavonoid content of 892,35 mg/100 g QE, while Punica granatum has total phenols of 125,24 mg GAE/g and total flavonoids of 57,96 mg QE/g. Antioxidant activity was measured through IC50 DPPH, with the lowest value in *Antidesma bunius* (15,84 µg/mL), indicating high antioxidant capacity. The effective dose of extracts varies, depending on the plant and the research model. For example, Zingiber zerumbet has an effective dose of 75 mg/kg BW for antidiabetic effects, while *Syzygium polychephalum* requires a higher dose (1000 mg/kg BW).

Overall, various Balinese local plants can be used as potential therapeutic agents for diabetes, obesity, hyperlipidemia, and atherosclerosis through different mechanisms, mainly based on antioxidant activity and modulation of major metabolic pathways.

Murraya paniculata Jacq. leaf extract contains secondary metabolite compounds: tannin (gallate), quinones, flavonoids, alkaloids and steroids. The effective dose of Kemuning leaf ethanol extract as anti-obesity is a dose of 200 mg/BB rats. *Murraya paniculata* Jacq. leaf ethanol extract does not suppress appetite, does not affect stool consistency, does not cause a laxative effect, and cannot reduce liver fat deposition [7]. *Murraya paniculata* Jacq. stem bark contains Flavonoids with 892.35 mg/100 g QE, Phenols 2089.345/100 g GAE and Tannin 1876.87 mg/100g GAE. In Kemuning Bark Extract, Tannin, phenol, and flavonoid compounds can inhibit the work of 3-Hydroxy-3-methylglutaryl coenzyme HMG Co-A reductase. The extract of 69 g/150 BW showed the highest LDL-lowering ability with a percentage reduction of 50,03% [6].

Zingiber zerumbet contains Zerumbon, the main isolated compound found in the rhizomes of Zingiber family plants and is known to have antidiabetic activity both in extract form and through virtual research. In addition, the xanthorrhizol compound in Lempuyang Wangi (*Zingiber zerumbet*) isolated and indicated to be used as a drug because the active compound zerumbon can inhibit aldose reductase protein. Xanthorrhizol has been shown to have various biological properties such as antioxidants, antihyperglycemic, antihypertensive, and hepatoprotective. The aqueous extract of *Zingiber zerumbet* was tested for its anti-inflammatory activity against acute inflammatory mode (PGE-2-induced paw oedema) in pre-treated rats in a certain concentration (50-100 mg/kg). Positive results were concluded. *Zingiber zerumbet* is reported to have anti-inflammatory potential [8].

Antidesma bunius Spreng. has been reported to contain anthocyanins, which possess antioxidant and antihypertensive actions. We investigated the inhibitory activity of anthocyanin-enriched fraction of *Antidesma bunius* fruit extract (ABE) against pancreatic α-amylase, intestinal α-glucosidase (maltase and sucrase), protein glycation, as well as antioxidant activity. The findings suggest that ABE may be a promising agent for inhibiting carbohydrate digestive enzyme activity, reducing monosaccharide-induced protein glycation, and antioxidant activity [19]. *Antidesma bunius* Spreng. team-blanched had the highest pancreatic lipase inhibition activity (17.8-37.4% for CC and 29.2-39.0% for KC), regardless of maturity stage, while water-blanched samples exhibited the highest cholesterol micellar solubility inhibition (39.6-42.2% for CC and 40.2-47.6% for KC) [9].

Antioxidant potential of Maja (*Aegle marmelos*) was shown to be quite impressive. The enzymes α-amylase and α-glycosidase were found to be substantially inhibited by *A. marmelos*, with IC50 values of 46.21 and 42.07 mg/mL, respectively. In HepG2 cells, *A. marmelos* significantly reduced elevated ROS levels due to high glucose and enhanced glucose consumption ($p < 0.05$). These activities might be due to the enrichment of bioactive phytoconstituents analyzed chromatographically using GC/MS and HPLC. The findings of this study show that *A. marmelos* could be an effective restorative therapy for diabetes and related diseases [20].

The ethanol extract of *A. altilis* leaves at *a*≤ 400 mg/kg dose showed no toxicity in the subchronic phase. The results of this study support the safety of using extract of *A. altilis* as a herbal medicine candidate [21]. Applying capsules containing dry extract of *A. altilis* leaves at a dose of 500 mg once a day for 21 days in diabetic patients showed significant results. This study noted that fasting blood sugar (FBS) levels in the intervention group decreased by -88.47 ± 88.01, while in the control group, it decreased by -33.90 ± 53.53 with a p-value = 0.024. These results showed a significant difference between the two groups ($p < 0.05$), where the intervention group experienced a more significant decrease in FBS. The effect of reducing fasting blood sugar levels is thought to be related to the flavonoids and other non-nutrient compounds in *A. altilis* leaves, which play a role in controlling glucose levels in patients with diabetes mellitus [11].

Ethyl acetate fraction *Syzygium polycephaum* Miq with IC50 value of 16.728 μg/ml and ethanol fraction with IC50 value of 7.567 μg/ml. This shows that the ethyl acetate and ethanol fraction show strong antioxidant activity and significantly correlate with the IC50 of alpha-glucosidase enzyme inhibition. Based on these findings, the kupa plant (*Syzygium polycephaum* Miq) has the potential to be developed as a source of natural antioxidants as well as an alternative therapy for diabetes [12].

Bioactive compounds in E. *grandiflorus* that act as antidiabetics include quercetin, kaempferol, and orientin. These three compounds contribute to the insulin receptor pathway mechanism to help lower blood glucose levels. In addition, E. *grandiflorus* cell culture extract has been shown to have a hypoglycaemic effect on hyperglycaemic rats, with an optimal dose of 100 mg/kg body weight [13]. The most significant weight loss occurred in rats that received ethanol extract of E. *grandiflorus* leaves at a dose of 400 mg/kg body weight [22].

The ethanol extract of Vitis vinifera L. Var. Alphonso Lavallee contains various phytochemical compounds, including terpenoids, saponins, flavonoids, carotenoids, and tannins. The results showed that 96% ethanol extract of Bali grape at a dose of 200 mg/kgBW and 400 mg/kgBB was able to increase the number of pancreatic beta cells [14, 23]. The average total phenolic content in 90% ethanol concentration at pH 3 was 5178,953 mg GAE/100 g, with a total anthocyanin content of 12,363.90 mg/L. The antioxidant capacity of Bali grape peel extract was recorded at 3657.31 mg GAEAC/100 g. The IC50 value obtained was 53.95 ppm with 70% ethanol concentration at pH 4, which falls into the strong antioxidant activity category[24].

The ethanol extract of *Impatiens balsamina* L.flower contains alkaloid, terpenoid, saponin, phenolic and flavonoid compounds. The IC50 value found in red water henna flower extract was 327,01 ppm [25]. The significant antihyperlipidemic activity of the methanolic extract of *Impatiens balsamina* flowers was observed at a dose of 400 mg/kg. Histopathological analysis of the rat liver also showed similar results. This study provides strong evidence of the antihyperlipidemic potential of the methanolic extract of *Impatiens balsamina* flowers, with no adverse effects observed at the tested dose[15].

Qualitative testing revealed that marigold leaf extract contains various bioactive compounds, including alkaloids, anthocyanins, betacyanin, cardiac glycosides, coumarins, flavonoids, glycosides, phenolics, quinones, saponins, terpenoids, and tannins. The antioxidant capacity of the extract, with an IC50 value of 145,79 µg/mL, indicates that marigold leaf extract possesses moderate antioxidant activity[26]. Phytochemical screening results indicated that the aqueous extract of marigold flowers contains flavonoids, phenols, alkaloids, and tannins. Meanwhile, the antioxidant activity test revealed an IC50 value of 50,77 ppm. Based on these findings, it can be concluded that the aqueous extract of marigold flowers possesses medicinal potential with strong antioxidant activity[27]. *T. erecta* flower extract can inhibit in a dose-dependent manner the enzymes α-glucosidase and pancreatic lipase. Concerning the inhibitory activity against the α-glucosidase enzyme, the polyphenol-rich extract of *T. erecta* showed high inhibition. The tested extract reduced the fat content in N2 wildtype strains at a 500 µg/mL concentration. This study showed that *T. erecta* flower extract rich in polyphenols has antidiabetic and antiobesity properties by reducing fat content [28]. *T. erecta* flower extract at 25 mg/kgBB, 50 mg/kgBB, and 75 mg/kgBB can reduce blood glucose levels. The best treatment dose is 25 mg/kgBB, which decreases by 70% compared to other doses [16].

Inhibiting α-amylase is crucial for diabetes management as it slows carbohydrate breakdown, controlling postprandial blood sugar spikes. *Vitex trifolia* extract (25–100 mg/mL) significantly inhibits α-amylase *in vitro*, with a maximum inhibition of 67% at 100 mg/mL. This effect helps reduce hyperglycaemia, a common issue in diabetes management. The inhibition likely results from interactions between polyphenols and flavonoids in the extract with the enzyme's active site, preventing effective carbohydrate breakdown. Beyond enzyme inhibition, these plant compounds also possess antioxidant properties, offering additional therapeutic benefits by reducing oxidative stress, further supporting their antidiabetic potential [17].

The effects of pomegranate peel extract (*Punica granatum*) on atherosclerosis progression in Apoe -/- mice indicate that administering the extract reduces plaque necrosis and increases collagen content in atherosclerotic lesions. Additionally, the extract improves metabolic profiles by lowering glucose, cholesterol, and triglyceride levels. These benefits are linked to enhanced macrophage efferocytosis through increased Mertk receptor expression, which facilitates the clearance of dead cells and reduces inflammation within plaques. Mertk (MER tyrosine kinase) is a tyrosine kinase receptor that plays a crucial role in the process of efferocytosis, the clearance of apoptotic (dead) cells by macrophages [29]. This receptor helps regulate inflammation resolution by preventing dead cell accumulation, which can trigger chronic inflammation, such as in atherosclerosis. Thus, pomegranate peel extract shows potential as a natural therapeutic agent for slowing atherosclerosis progression [18].

Several plants show high antioxidant content with significant potential health benefits. *Murraya paniculata* Jacq. or kemuning, especially in the stem bark, has a flavonoid content of 892,35 mg/100 g QE, phenol 2089,345 mg/100 g GAE, and tannin 1876,87 mg/100 g GAE. These compounds play a role in reducing LDL levels by inhibiting the enzyme HMG Co-A reductase, with the effectiveness of reducing LDL up to 50,03% at certain doses. In addition, *Vitis vinifera L.* Var. Alphonso Lavallee, or Balinese grape, has total phenolics of 5178,953 mg GAE/100 g, total anthocyanins of 12,363mg/L, and antioxidant capacity of 3657.31 mg GAEAC/100 g, which has the potential to increase the number of pancreatic beta cells and function as an antihyperglycemic agent.

Another plant that also has high antioxidant activity is *Syzygium polycephalum* Miq. (kaliasem) with a DPPH IC50 of 7,567 µg/ml in the ethanol fraction, which shows a strong ability to inhibit the α-glucosidase enzyme so that it has potential as an alternative therapy for diabetes. *Antidesma bunius* Spreng. (buni) contains anthocyanins with IC50 DPPH of 15,84 µg/mL, which can inhibit carbohydrate digestive enzymes (α-amylase and α-glucosidase), and has antihypertensive effects. Meanwhile, *Aegle marmelos* (maja) showed antioxidant activity with IC50 DPPH of 42,07 ppm, able to inhibit α-amylase and α-glucosidase and reduce oxidative stress in HepG2 cells, so it has potential as a restorative therapy for diabetes. In addition, *Elaeocarpus grandiflorus* (rijasa) contains quercetin, kaempferol, and orientin, which play a role in improving insulin sensitivity and losing weight.

The various plants studied, *Murraya paniculata* (stem bark) and *Vitis vinifera L.* Var. Alphonso Lavallee (Bali grape skin) had the highest antioxidant compound content, followed by *Syzygium polycephalum*, *Antidesma bunius*, and *Aegle marmelos*. These plants show great potential in developing natural therapies for degenerative diseases such as diabetes, hyperlipidemia, and conditions related to oxidative stress.

Conclusion

Several Balinese local plants exhibit promising mechanisms in addressing degenerative diseases. *Murraya paniculata, Artocarpus altilis, Aegle marmelos, Elaeocarpus grandiflora, Syzygium polycephalum, Antidesma bunius, Vitex trifolia*, and *Tagetes erecta* have antidiabetic properties by inhibiting α-glucosidase and α-amylase enzymes, enhancing insulin sensitivity, and protecting pancreatic cells from oxidative stress. *Zingiber zerumbet* and *Impatiens balsamina* possess anti-inflammatory and antihyperlipidemic effects, helping regulate lipid metabolism and prevent metabolic complications. *Vitis vinifera* L. Var Alphonso Lavallee and *Punica granatum* demonstrate antihyperglycemic and cardioprotective effects by promoting pancreatic β-cell regeneration and reducing inflammation and atherosclerosis risk. Additionally, Tagetes erecta and Murraya paniculata combat obesity by inhibiting lipase enzyme activity and limiting fat absorption. These findings highlight the potential of Balinese plants in natural therapies for diabetes, hyperlipidaemia, and obesity. Further research is needed to optimize active compound standardization, assess long-term efficacy and safety, and develop herbal formulations. Future studies should explore clinical trials, bioavailability, and synergistic effects to enhance therapeutic potential. Integrating these findings into phytopharmaceutical development could support the commercialization of Balinese herbal medicine, offering sustainable and evidence-based alternatives in modern healthcare.

Author's Contribution

Ida Ayu Manik Damayanti: The author was responsible for conceptualizing the study, conducting the literature search, analyzing and synthesizing relevant information, and drafting the manuscript.

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