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A Bibliometric Analysis of *Physalis angulata*, an Underexplored Agri-Food Resource for Diabetes Management

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A B S T R A C T

Diabetes remains a major global challenge, including in Indonesia. The long-term use of commercial drugs may cause adverse effects, highlighting the need to explore natural alternatives. *Physalis angulata* (*P. angulata*) is a traditional medicinal plant in Indonesia with potential for diabetes treatment, yet it remains underexplored. Although several studies have examined its biological properties, bibliometric analyses are still limited. This study aims to analyze scientific publications from 2000 to 2025 on the use of *P. angulata* in the treatment of diabetes. A total of 288 documents from Scopus, PubMed, and Google Scholar were analyzed using VOSviewer to examine publication trends, keyword usage, and experimental studies. The results show a steady increase in publications, peaking in 2025 with 32 documents. The Journal of Ethnopharmacology is the leading publisher in this field. Keyword analysis links *P. angulata* to medicinal plants, ethnobotany, phytochemistry, and biological activity, while diabetes-related studies are largely limited to in vitro and in vivo research, with no clinical trials or food product development reported. Experimental evidence indicates that *P. angulata* contains bioactive compounds with antihyperglycemic, antioxidant, and organ-protective effects, particularly for the pancreas and kidneys. Recent studies also explore molecular mechanisms using docking approaches. In conclusion, *P. angulata* shows strong potential as an agri-food-based bioactive source for diabetes management. However, further research is needed, particularly to standardize extracts, conduct clinical validation, and develop functional food products supported by robust scientific evidence.

Contribution to Sustainable Development Goals (SDGs):

SDG 2: Zero Hunger

SDG 3: Good Health and Well-being

SDG 12: Responsible Consumption and Production

SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Diabetes mellitus, especially type 2 (T2DM), has emerged as a major global health crisis in the 21st century. The International Diabetes Federation estimates that around 588.7 million adults

had diabetes in 2024, with projections indicating an increase to 852.5 - 853 million by 2050. The sharpest increase is expected in low- and middle-income countries due to rapid urbanization and dietary changes [1]. The consequences of diabetes extend beyond clinical implications to encompass socio-economic factors. Chronic consequences, including cardiovascular disease, diabetes nephropathy, neuropathy, and retinopathy, necessitate extensive long-term care and diminish community output.



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The prevailing strategy for type 2 diabetes mellitus (DMT2) treatment predominantly depends on traditional pharmacological agents, including metformin, sulfonylureas, and insulin. While these are effective at controlling hyperglycaemia, they are often associated with limitations such as gastrointestinal side effects, the risk of hypoglycaemia, the cost of lifelong treatment, and a decrease in long-term effectiveness. Furthermore, conventional therapies focus more on glycemic control than on modifying the dietary and metabolic inflammatory factors underlying DMT2 pathogenesis. This treatment gap has generated increasing interest in complementary methods utilizing natural substances and functional foods that concurrently exhibit hypoglycaemic, antioxidant, and anti-inflammatory properties [2] [3].

This study explores the vast, yet largely unexplored, potential of tropical biodiversity as a source of bioactive compounds. One plant that is beginning to be noticed is *P. angulata* L., which is known in Indonesia as ciplukan or ceplukan. It is also known as the morel berry, golden berry or groundberry in other countries. This plant has historically been utilized to address many metabolic and inflammatory conditions, including diabetes [4][5]. Ethnobotanical research across Asia and Africa indicates the use of *Physalis* species for the treatment of metabolic disorders and chronic illnesses [6][7].

P. angulata includes withanolides, fisalin, flavonoids, and phenolic chemicals, all of which contribute to its diverse biological activity [8][9]. Experimental studies have shown that the plant's extract exhibits anti-hyperglycaemic effects in models of streptozotocin-induced diabetes [10], presumably by activating the insulin signalling pathway (IRS-1/Akt) and regulating GLUT-4 [11][12]. Furthermore, anti-inflammatory activity via modulation of NF- κ B, as well as protective effects against complications such as diabetic nephropathy, have been documented [13][14].

Although *P. angulata* shows promise in pharmacology, research on this plant is still limited compared to prominent antidiabetic botanicals such as *Cinnamomum verum* and *Momordica charantia*. Most studies are in the early stages of in vitro or in vivo animal testing or computational modelling, with very few clinical trials in humans. Furthermore, variances in plant parts and extraction procedures, as well as a lack of standardization of active chemicals, lead to contradictory research outcomes [15][16]. This suggests that standardizing raw materials, characterizing bioactive metabolites, and developing a more comprehensive understanding of the molecular mechanisms involved are significant areas for future research.

Alongside the growing demand for safe, locally sourced complementary therapies, the scientific exploration of *P. angulata* as an antidiabetic agent has become highly relevant. This study, therefore, uses a bibliometric review approach to map developments in publications, global research trends, scientific collaborations, and thematic focuses.

1.2. Literature Review

1.2.1. *Physalis angulata*

Physalis angulata is a herbaceous plant that grows widely in tropical and subtropical regions. It grows widely in open fields, gardens, and roadside places throughout Southeast Asia, including Indonesia. This plant, which is a member of the *Solanaceae* family, is easily identified by its tiny, round fruit that is covered in a papery husk. When ripe, the fruit is usually green

to yellowish and tastes slightly sweet. The plant often reaches 0.5 to 1 m in height and is easily cultivated and widely accessible due to its adaptability to a wide range of environmental conditions [17].

Significant antioxidant activity has also been discovered for *Physalis angulata*'s fruit and aerial parts, primarily due to their phenolic and flavonoid content. In biological systems, these substances are crucial for scavenging free radicals and lowering oxidative stress. Physalins have also been demonstrated to have cytotoxic and immunomodulatory properties, which adds to the plant's therapeutic potential [18].

Physalis angulata is potential for treating diabetes mellitus. Furthermore, this plant has been recognized by the public as an alternative medicine for breast cancer and antilithiasis, and it has natural antioxidant activity [19]. *Physalis angulata* L., sometimes referred to as camapu, wild gooseberry, or ciplukan, is a multipurpose, pantropical herbaceous plant that is well known for its therapeutic qualities and, more recently, for its potential as a functional food ingredient. It is a great option for sustainable, plant-based functional food applications due to its durability, high phytochemical content, and nutritional composition [20].

1.2.2. Diabetes mellitus

Diabetes mellitus (DM) is a chronic disease characterized by elevated blood glucose levels over a long period. This condition occurs due to a disruption in the production or use of insulin, a hormone that helps regulate glucose metabolism. Insulin is produced by the pancreas and helps the body's cells use glucose as an energy source. In individuals with diabetes mellitus, the body either cannot produce enough insulin (Type 1 Diabetes Mellitus or T1DM) or does not respond well to insulin (Type 2 Diabetes Mellitus or T2DM) [1].

Through ROS-induced oxidative stress and advanced glycation end products (AGEs), chronic hyperglycemia in diabetes causes serious consequences. By disrupting cell homeostasis and inducing systemic inflammation, these pathways induce microvascular and macrovascular damage that affects the eyes (retinopathy), kidneys (nephropathy), nerves (neuropathy), and cardiovascular system (atherosclerosis/heart disease) [21].

One of the main causes of diabetes is oxidative stress, which worsens insulin resistance and damages pancreatic cells by disrupting the balance between reactive oxygen species (ROS) and antioxidant defences. Hyperglycemic memory and its consequences, such as neuropathy and cardiovascular disease, are fueled by this long-term imbalance. Medicinal plants rich in antioxidants (flavonoids, alkaloids) offer a promising therapeutic approach to enhance glucose regulation and reduce oxidative damage [22].

1.2.3. Bibliometric review

Bibliometric analysis has emerged as a crucial tool for understanding the evolution of scientific inquiry within a particular topic. This method enables academics to evaluate trends in publishing output, citation patterns, and research productivity over time by methodically analyzing published literature. Additionally, it helps identify key contributors and significant studies by providing insight into networks of collaboration among authors, institutions, and nations. Software programs such as VOSviewer, Biblioshiny, and CiteSpace, which facilitate the visualization and comprehension of complex

bibliographic data, are widely used in practice to support bibliometric research. As a quantitative approach, it provides an organized means of investigating the evolution of knowledge and the connections across various fields of study [23].

Additionally, academics can uncover essential research themes and emerging areas using bibliometric techniques such as keyword co-occurrence, co-citation, and clustering analysis. These techniques help identify potential research gaps by revealing which topics have been well investigated and which remain comparatively unexplored. By displaying these patterns as networks and maps, the use of visualization tools further enhances their clarity. Because of this, bibliometric analysis is increasingly used to support strategic research planning, inform literature reviews, and provide a better understanding of the state of science across a variety of fields [24].

1.3. Research Objective

This analysis aims to identify research gaps and future development opportunities, particularly in standardization, clinical validation, and the development of phytopharmaceuticals or functional foods based on *P. angulata* for the management of type 2 diabetes mellitus.

2. MATERIALS AND METHODS

2.1. Data collection

References on the use of *P. angulata* as a medicinal plant for managing diabetes were sourced from the Scopus, PubMed and Google Scholar databases, which contain more extensive and comprehensive data. The databases were searched using the keywords '*P. angulata*' and 'diabetes'. The scientific literature searched for included one or more of these keywords, terms or phrases in the title, abstract or keywords of the research articles. The literature used was published within the last 25 years (2000–2025) and included research articles, review articles, and book chapters. The Scopus database search yielded 149 titles and abstracts, the PubMed database search yielded six, and the Google Scholar database search yielded 100. The articles were managed using Mendeley software to record, monitor, sort and check studies, resulting in 228 articles being included in the study. The data collection flowchart can be seen in Fig. 1.

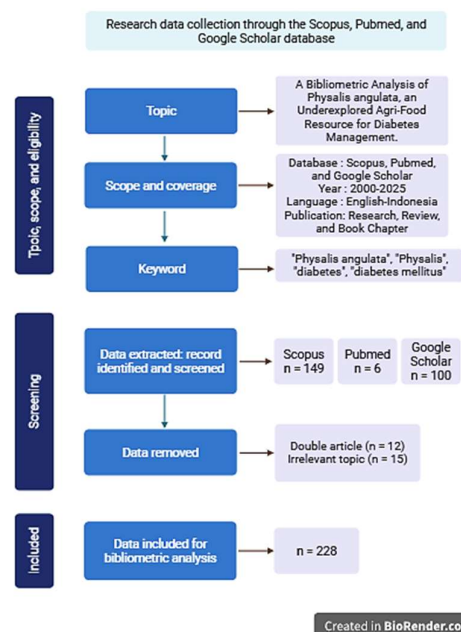


Fig. 1. Flowchart of data collection

2.2. Data extraction and analysis

Data extraction and analysis involved collecting information from existing scientific literature, including the titles, abstracts, and keywords of relevant articles. After extraction, the data is analyzed to gain an understanding of it. The collected literature was saved in '.RIS' format. This was then exported to Vosviewer 1.6.19 for bibliometric analysis. Parameters used include publication trends over 25-year periods, an analysis of journals contributing to scientific publications, a keyword co-occurrence network, a keyword overlay network by year, and a density network.

2.3. Term maps

VOSviewer is software that analyses and visualizes bibliometric data from a database of words extracted from the titles, abstracts, and keywords of selected literature. Data visualization takes the form of a bubble map, with each bubble representing a word or phrase from the literature. The size of each bubble indicates the number of citations in publications containing that word. The distance between two bubbles indicates how often two words appear together.

3. RESULT AND DISCUSSION

3.1. Trends of Publications

Based on data collected from the databases used (Scopus, PubMed, and Google Scholar), there has been an increasing trend in scientific publications on *P. angulata* as a medicinal plant for diabetes over the last two decades (2000–2025) (see Fig. 2).

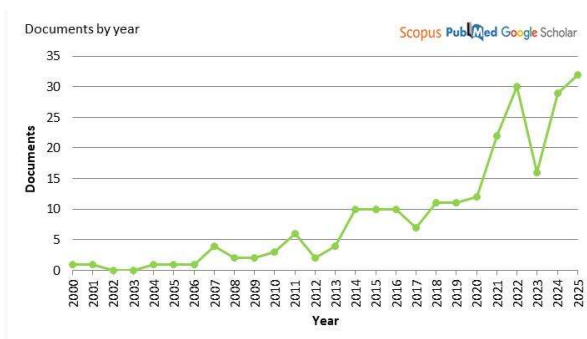


Fig. 2. Publication trends

As can be seen, in the early period (2000–2006) the number of publications was still very limited, with some years seeing none. This suggests that the study on *P. angulata* in the early 2000s was exploratory and not a major focus of international literature. Subsequently, the number of articles rose, peaking after 2020. Between 2021 and 2025, the number of publications increased substantially, reaching more than 20 articles per year, with over 30 documents in the final year. Although there were fluctuations in some years, this demonstrates that the field is still developing and has not yet stabilized. This publication trend indicates that *P. angulata* is being studied not only as an

ethnomedical plant, but also as a source of bioactive compounds and phytopharmaceuticals for the agri-food industry.

This study examined publications reporting studies on *P. angulata* as a medicinal plant for diabetes, along with the number of papers. The Journal of Ethnopharmacology was the most popular journal for publishing studies on *P. angulata*, with about 34 documents, according to an analysis of these papers' sources. This predominance implies that the primary approach to studying this plant is still ethnopharmacology. This suggests that the majority of research is still focused on identifying active compounds, evaluating biological activity during the preclinical phase, and providing evidence to support traditional use. More targeted actions are required to fully realize *P. angulata* potential as a source of bioactive compounds for diabetes treatment, especially in agronomy and food technology, given the growing number of publications on the plant. This will help to strengthen the evidence base for its use.

3.2. Keyword co-occurrence network

The co-occurrence network visualization of terms illustrates the major theme clusters that comprise the intellectual structure of the *P. angulata* study (Fig. 3). The proximity of the lines indicates the strength of the association between topics, while the size of the bubbles represents the frequency of keyword occurrence.

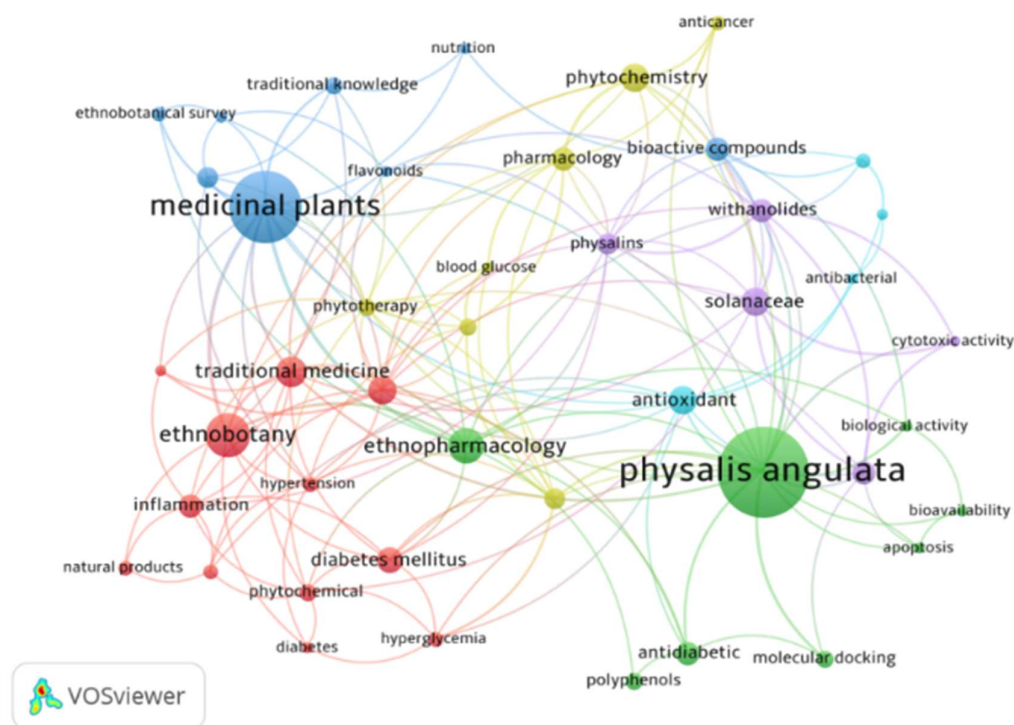


Fig. 3. Keyword co-occurrence network

P. angulata," which was directly associated with phrases such as "antioxidant," "antidiabetic," "bioactive compounds," and "ethnopharmacology," was the largest bubble to emerge. This suggests that investigating the biological activity and pharmacological potential of this plant remains the primary focus of research. There are multiple keyword clusters in the keyword co-occurrence visualization. Terms like "ethnobotany,"

"traditional medicine," "diabetes mellitus," "inflammation," and "hyperglycemia" are prevalent, as indicated by the red cluster. The early application of *P. angulata* research, which came from traditional use, is exemplified by this cluster.

The tight connection between ethnobotany and diabetes demonstrates that communities' empirical claims about the plant's potential to treat metabolic illnesses are a major catalyst for scientific investigation.

Another noteworthy cluster (yellow-purple) focuses on "phytochemistry," "bioactive compounds," "withanolides," and "physalins." The emergence of these terms suggests that one of the scientific fields involved in the advancement of *P. angulata* research is natural product chemistry. Additionally, the presence of terms such as "molecular docking" and "bioavailability" suggests that pharmacokinetic and computational approaches are increasingly being integrated into research, though this remains less extensive than fundamental phytochemical studies. Additionally, terms like "antidiabetic," "polyphenols," "apoptosis," and "biological activity" are included in the green cluster. This illustrates that pharmacological effects, such as the regulation of oxidative stress and cellular signalling pathways, are the main focus of research. However, the notion that the majority of research is still in the preclinical stage is reinforced by the comparatively little association with phrases like "clinical trial" or "human study."

This visualization shows that research on *P. angulata* remains concentrated on three main axes: ethnomedical documentation and validation, phytochemical characterization and isolation of active compounds, and evaluation of biological activity at the in vitro and in vivo levels. There is still a lack of food-based development research or controlled clinical trials. This suggests there is ample room for further study, especially in applications such as phytopharmaceuticals and functional foods derived from regional agricultural resources.

3.3. Keyword overlay network

Keyword overlay network mapping offers a more dynamic representation of the trajectory of *P. angulata* research over the past 25 years (Fig. 4). Unlike co-occurrence networks, this representation enables observation of shifts in study focus through colour gradations from older publications to the most recent studies.

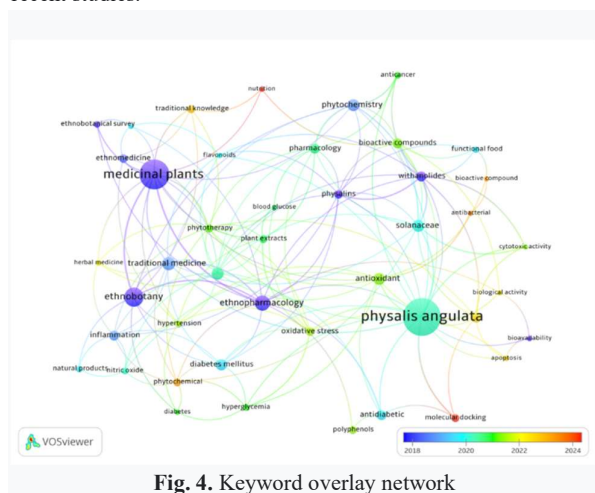


Fig. 4. Keyword overlay network

The overlay visualization displays phrases like "medicinal plants," "ethnobotany," "ethnomedicine," and "traditional medicine" in darker hues (dark blue), signifying that this research has a longstanding history, particularly before 2018 when examined on a timeline. Accordingly, rather than being cultivated as a food commodity, *P. angulata* has been explored for its benefits in traditional and indigenous medicine. Within the same time frame, the phrases "withanolides," "physalins," "bioavailability," and "phytochemistry" also point to a time

before 2018, indicating that the isolation of bioactive compounds from *P. angulata* has been investigated, thereby bolstering the assertion of its traditional therapeutic potential.

Additionally, as the green-cyan term visualization shows, *P. angulata* has been associated with studies concerning "diabetes mellitus," hyperglycemia, blood glucose, and "antidiabetic" between mid-2020 and 2022. This supports the idea that *P. angulata* has the potential to be an antidiabetic drug, attracting research interest. Molecular docking and nutrition-related red keywords are visible in 2024. The existence of molecular docking studies suggests that *P. angulata* is starting to be investigated and integrated into computational methods. In the meantime, the term "nutrition" suggests that *P. angulata* is increasingly being considered not only for its bioactivity but also for its nutritional value.

P. angulata's use as an antidiabetic drug is still restricted in ethnobotanical research, chemical isolation, and bioactivity testing, as can be seen from the keyword overlay visualization. Although it has great potential for future growth, its use in creating functional foods with antidiabetic properties is still quite limited.

3.4. Keyword overlay network

The keyword density network visualization provides an overview of the concentration and intensity of topics that most frequently appear in the literature on *P. angulata*. On this map, the yellow-red areas indicate high-density (the most frequently researched topics), while the green-blue areas represent lower-frequency topics (Fig. 5).

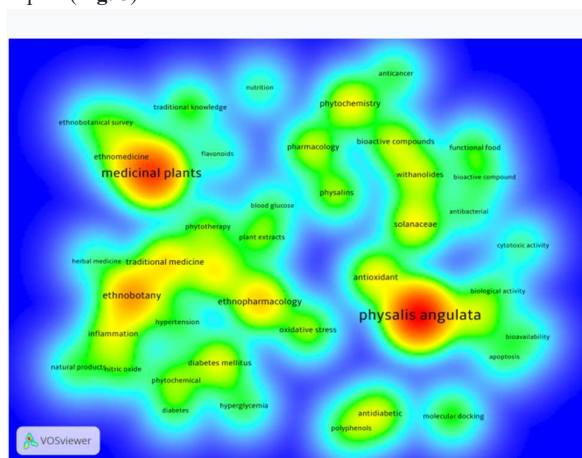


Fig. 5. Density network visualization

The density network visualization clearly shows that the keyword *P. angulata* is in the middle, with the highest colour intensity (orange-red). This is fair, given that this phrase is the primary subject of literature searches. What is intriguing is the high density of other keywords surrounding the term "medicinal plants." This density implies that *P. angulata* is theoretically classed as a medicinal plant with a documented research record, rather than simply a food item or raw material for the health industry.

Keywords with high density can also be found in the clusters of "ethnobotany," "ethnomedicine," "traditional medicine", and "ethnopharmacology". This confirms prior analyses that the base of research on this plant is firmly rooted in documentation of its

traditional use. In other words, *P. angulata* remains strongly tied to the field of ethnopharmacology.

On the other side, phrases like “antioxidant”, “phytochemistry”, “bioactive chemicals”, and “withanolides” fall into a medium-density zone. This suggests that, after ethnobotanical research, the investigation of chemical content and biological activity is the second most common theme. Much of the study focuses on isolating active compounds and assessing their basic biological properties, such as antioxidant and cytotoxic effects. Diabetes-related keywords such as “diabetes mellitus”, “hyperglycemia”, and “antidiabetic” have a lower density than the “ethnobotany” and “phytochemistry” clusters, indicating that antidiabetic research on *P. angulata* is still in its early stages. Similarly, terminology such as “molecular docking,”

“bioavailability,” and “nutrition” remains uncommon, indicating that computational techniques and food-based development have not been well studied.

3.5. Experimental studies on the antidiabetic potential of *P. angulata*

Based on 28 experimental studies from the collected documents, it appears that research into *P. angulata*'s antidiabetic potential has moved from basic activity testing to more complicated molecular techniques (Table 1). In general, in vivo investigations using animal models of diabetes induced by alloxan or streptozotocin remain dominant. This indicates that the research and development stage is still in the preclinical phase.

Table 1. Experimental studies on the antidiabetic potential of *P. angulata*

No	Study design	Plant part	Model	Key findings	Reference
1	In vivo	Whole herb extract	Alloxan-induced diabetic mice	Significantly reduced blood glucose levels	[25]
2	In vivo	Extract and fractions	Alloxan-induced diabetic rats	Demonstrated antihyperglycemic activity and improved metabolic parameters	[26]
3	In vivo	Standardized physalin extract	Streptozotocin-induced diabetic rats	Improved pancreatic function and insulin secretion	[27]
4	In vitro	Fruit extract	Enzyme inhibition assay	Showed α -amylase inhibitory activity related to glucose metabolism	[28]
5	In vivo	Isolated compound from fruit	Alloxan-induced diabetic rats	Reduced blood glucose and improved antioxidant status	[29]
6	In vitro / In vivo	Physagulin-F	Enzyme inhibition and diabetic rat model	Demonstrated α -glucosidase inhibitory and antihyperglycemic effects	[30]
7	In vitro	Whole plant extract	3T3-L1 adipocytes	Increased glucose uptake and reduced lipid accumulation	[31]
8	In vivo	Whole plant extract	Alloxan-induced diabetic rats	Exhibited antioxidant and renoprotective effects	[32]
9	In vivo	Ethanol extract	Diabetic rat model	Improved lipid profile and reduced dyslipidemia	[33]
10	In vivo	<i>P. angulata</i> + <i>Hibiscus sabdariffa</i>	Diabetic rats	Reduced blood glucose and improved pancreatic histology	[34]
11	In vitro	Physagulin-F	Enzyme inhibition assay	Strong inhibition of α -amylase and α -glucosidase	[35]
12	In vitro	Ethanol extract	Enzyme inhibition assay	Demonstrated antioxidant and antidiabetic enzyme inhibition activity	[36]
13	In vivo	Leaf ethanol extract	Diabetic Wistar rats	Reduced hyperglycemia and oxidative stress markers	[37]
14	In vivo	Herb ethanol extract	Diabetic hypercholesterolemic hamsters	Exhibited antihyperglycemic and hypolipidemic effects	[38]
15	In vivo	Fruit juice	Streptozotocin-induced diabetic rats	Decreased blood glucose and improved metabolic profile	[39]
16	In vivo	Fruit juice	Diabetic rats	Improved liver histopathology and lipid profile	[39]
17	In vitro	Active fraction	Myoblast cell assay	Increased glucose consumption indicates antidiabetic potential	[40]
18	In vivo	Extract	Hyperglycemic rat model	Ameliorated diabetic nephropathy parameters	[41]
19	In silico	Active fraction compounds	Molecular docking	Predicted inhibition of TGF- β related to diabetic nephropathy	[13]
20	In silico	GC-MS identified compounds	Molecular docking	Potential interaction with the GLUT-4 receptor	[12]
21	In vitro	Fruit extract	Endothelial cell model	Improved cell migration and VEGF levels under hyperglycemia	[42]
22	In vivo	Fruit extract	Gestational diabetic mice	Reduced oxidative stress and inflammatory cytokines	[43]
23	In vitro	Active fraction	Insulin signalling assay	Increased IRS-1 and Akt phosphorylation	[11]
24	In vivo	Extract fraction	Diabetic rat reproductive model	Reduced oxidative stress and tissue damage	[44]
25	In vivo	Extract	Diabetic rat model	Reduced angiotensin II and blood glucose levels	[45]
26	In vivo	<i>P. angulata</i> + <i>Cinnamomum burmannii</i>	Diabetic rats	Improved glucose, lipid profile, inflammatory markers and pancreatic histology	[46]
27	In silico	Bioactive compounds	Network pharmacology and docking	Predicted multiple antidiabetic molecular targets	[47]
28	In vitro	Phytochemical extract	Enzyme inhibition assay	Demonstrated antioxidant and metabolic enzyme inhibition activity	[48]

In general, several trends can be identified: the consistent antihyperglycemic effect across various animal models; antioxidant and anti-inflammatory activities that often accompany the glucose-lowering effect; the emergence of molecular mechanisms and the exploration of specific targets; and the lack of controlled clinical trials in humans.

The most prominent research gaps are the lack of clinical studies and the lack of standardized extracts. In addition, there is no standardization of raw materials and marker compounds, chronic toxicity and long-term safety testing, controlled clinical trial designs in type 2 diabetes patients, or exploration of food-

based formulations or delivery systems to improve bioavailability. Using a more integrated, translational approach, research on *P. angulata* can progress from the experimental exploration stage to the development of products supported by stronger scientific evidence.

4. CONCLUSION

Based on bibliometric analysis and reviewed experimental studies, *P. angulata* shows consistent potential as a candidate antidiabetic agent, particularly through its antihyperglycemic,

antioxidant, and protective effects on target organs. However, most of the evidence is still at the preclinical stage (in vitro and in vivo), with limited clinical trials in humans. Although research trends continue to increase, standardization of extracts, validation of molecular mechanisms, and controlled clinical studies are still needed to strengthen the scientific basis for its development. With a more integrated approach, *P. angulata* has the potential to be developed as a bioactive source for agri-food or phytopharmaceutical applications in the management of type 2 diabetes.

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