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Herbal Medicine as an Alternative Management for Prediabetes: A Review

Rina Amelia[1*], Muhammad Fadli Putra Pahlevi[2], Ahmad Avicenna Ash-Shiddiq Ikhsan[2], Nanda Andini[2], Salsabila Nadyah[3]

[1] *Department of Community Medicine, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia*
[2] *Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia*
[3]*Faculty of Medicine, Andalas University, Padang, Indonesia*

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ABSTRACT

Prediabetes refers to a state of dysglycaemia, a transitional phase between normoglycaemia and diabetes. Early identification of prediabetes, followed by appropriate management and treatment, is vital to prevent its progression to diabetes, which is an incurable condition. A widely available and rapidly developing therapy option is herbal medicine. This systematic review examines various herbal medications that can be utilised as therapy for prediabetic patients. Literature was obtained through searches in online journal databases such as Pubmed and Cochrane according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) stages. The keywords are herbal or "herbal medicine", "traditional medicine" or "alternative medicine", and prediabetes or "impaired glucose tolerance" or "impaired fasting glucose". A total of 7 journals were included in this study. Various plants utilised as herbal medicine have been researched and published for their efficacy and safety as prediabetes therapy such as *Panax ginseng* Meyer (enhancing β cell function and increasing insulin sensitivity), Tang-Yi-Ping (improving pancreatic β-cell proliferation and protecting β-cell number and function), Jinlida granules (producing a significant reduction in blood glucose levels 2 hours postprandial and HbA1c levels), *Allium hookeri* (reducing the inflammatory response to hyperglycemia), Nisha-Amalaki capsules (having insulin sensitising effects), *Trigonella foenum-graceum* (stimulating pancreatic beta cells), and *Moringa oleifera* nanoparticles (MoNP) (regulating inflammatory cytokines; increasing the activity of glucokinase enzymes and pancreatic β-cells, lowering insulin resistance, and activating GLUT-4). In conclusion, herbal medicine is known to provide promising results for the treatment and prevention of prediabetes.

Keywords: Prediabetes, Herbal or traditional medicine, Impaired glucose tolerance

Introduction

Dysglycaemia that occurs in between normoglycaemia and diabetes is referred to as prediabetes. Laboratory measures of fasting blood glucose (FBG), glycosylated haemoglobin (HbA1C), or 2-hour postprandial blood glucose are used to diagnose prediabetes. People who are at risk of becoming diabetic in the future are referred to as having prediabetes. High cardiometabolic risk factors are also linked to diabetes. Prediabetes is a serious public health concern and a warning indicator for the growing diabetes epidemic, and its repercussions are the increased frequency of diabetes worldwide. The increased frequency of prediabetes internationally is a significant public health issue that may further complicate the expanding epidemic of diabetes and its complications.[1]

Comprehensive global prediabetes prevalence data is still insufficient. In 2019, the International Diabetes Federation (IDF) predicted a 7.5% global prevalence of impaired glucose tolerance (IGT) in men and women. The projection is for approximately 374 million adults aged 18-99 years, with roughly half (48.1%) under 50 and around one-third (28.3%) between the ages of 20 and 39.

*Corresponding author. E mail: rina2@usu.ac.id
Tel: : +62-811-6180-352

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Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

Young people with prediabetes are more prone to develop complications later in life. The majority of people with prediabetes (72.2%) live in low- and middle-income nations, with the North America and Caribbean region having the most significant prevalence of IGT (13.8%) and Europe having the lowest (5.1%).[1] Early detection of prediabetes, followed by effective management and therapy, is critical to preventing the development of diabetes, which is an irreversible illness. Herbal medicine is a popular and fast-increasing treatment alternative.

The alternative medicine system based on plant extracts evolved over millennia and is still used by many people to treat various ailments. The World Health Organization defines herbal medicine as using herbs, herbal materials, herbal preparations, and finished herbal products that contain active substances derived from plant parts, other plant materials, or mixtures. Plant materials used in herbal medicines include leaves, stems, flowers, roots, and seeds. Medicinal plants have been used as a source of medicine worldwide, with 80-85% of the population relying on their extracts or active components as traditional medicine to address primary healthcare needs.[2] According to the literature, diabetes mellitus (DM) patients who are unsatisfied with conventional treatment are more prone to take herbal medicine to boost its effectiveness. However, using herbal medicine alongside conventional therapy might result in potentially dangerous herbal-drug interactions, which can harm patient outcomes. Herbal medicines are typically complex combinations of multiple active ingredients, which increases the possibility of interactions. St. John's wort (SJW) dramatically enhances gliclazide clearance, while Ginkgo biloba extract treatment increases hepatic clearance of insulin and oral hypoglycemic medications, raising glucose levels. Diabetes patients in China have reported side effects such as hypoglycemia and lactic acidosis after taking herbal anti-diabetic drugs. These undesirable responses can include all systems, age groups, and

severity levels.[3] Therefore, it is of utmost importance that herbal medicines (for local and commercial use) must first undergo a series of efficacy and safety tests.
Various research literature on the efficacy of herbal medicine for prediabetes has been published. This systematic review examined various herbal medications that can be utilised as therapy for prediabetic patients.

Material and Methods

This research is a systematic review of the literature relating to prediabetes. Literature was obtained through searches in online journal databases such as PubMed and Cochrane. This study only included journals that met the inclusion and exclusion criteria and had undergone a quality review. The literature search used the PRISMA stages (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The research includes English-language journals discussing herbal medicine use for prediabetic patients. The journal selection is limited to those published from June 9, 2016, until June 9, 2024. The types of studies included are clinical trials and randomised controlled trials. Inclusion and exclusion criteria are presented in Table 1.
The journal search uses the Boolean search method with the keywords (herbal OR "herbal medicine" OR "traditional medicine" OR "alternative medicine") AND (prediabetes OR prediabetes OR "impaired glucose tolerance" OR "impaired fasting glucose"). The data collected includes (1) author, (2) year, (3) country, (4) objective, (5) sample, (6) research design, (7) research duration, (8) research results, and (9) conclusion. The Mendeley free reference manager was used in this study.

Table 1: Inclusion and exclusion criteria for articles reviewed.

PICOS	Inclusion Criteria	Exclusion Criteria
Patients	Prediabetes/impaired glucose tolerance patient	Type-1 or type-2 diabetes mellitus
Intervention	Administration of herbal medicine	
Comparison	Administration of placebo or modern anti-diabetes medication	
Outcome	Improvement in fasting blood glucose levels, postprandial glucose levels, HbA1C, or insulin resistance	
Study Design	Clinical trial or randomised controlled trial with open-access journal	Meta-analysis, systematic review, review, books and documents, paid journal

Footnotes: PICOS: Patient, intervention, comparison, outcome, and study design.

Results and Discussion

Using the established keywords, journal searches through Cochrane and PubMed yielded 326 articles. The excluded articles include 174 paid journals, 102 journals with inappropriate research designs, 23 journals published more than 5 years ago, and 15 journals with titles and abstracts that were not relevant. A total of 7 articles met the inclusion criteria for this review (Table 2). The literature search, exclusion and inclusion of articles flow chart are presented in Figure 1.
Prediabetes is a transitional state from hyperglycaemia, with glucose indices above normal but below the diabetes threshold. Laboratory measures of fasting blood glucose (FBG), glycosylated haemoglobin (HbA1C), or 2-hour postprandial blood glucose can be used to identify prediabetes. The term prediabetes refers to persons who are at risk of developing diabetes in the future; nevertheless, prediabetes is also associated with significant cardiometabolic risk factors and a bad prognosis.[1] Any level of hyperglycemia, from intermediate to full-scale diabetes, appears to carry the risk of impairing physiological function through glycation mechanisms, including those of the endothelium and platelets. The haemostatic disorder of diabetes is exacerbated by platelet activation that follows glycation and also results from endothelial dysfunction. As a crucial component of haemostasis, vascular function interacts with the pathophysiology of various illnesses, including diabetes, where it significantly mediates organ involvement and overall morbidity. Therefore, it is essential to pay attention to the significance of the prediabetic state. Prompt identification of the prediabetic state offers the chance of reversal and, as a result, the prevention of additional consequences.[4]
Metformin, acarbose, and troglitazone are examples of pharmacological therapies used to treat prediabetes. However, current treatment, which focuses on blood sugar regulation, has limitations in treating diabetes and its complications, and some unpleasant effects can arise after long-term use. Hence, researchers and health practitioners worldwide are investigating and developing alternative diabetes treatments. Herbal medicines showed promise as an alternative therapy. Herbal medicine is a treatment with one or more active components extracted from plants and plant-based medical preparations.[5] Various plants utilised as herbal medicine have been researched and published for their efficacy and safety as prediabetes therapy.

Panax ginseng Meyer (ginseng).
Ginseng has been used as a traditional medicine in treating metabolic diseases, cancer, cardiovascular diseases, and other ailments in several Asian countries. Ginseng produces antidiabetic effects through several mechanisms. Ginseng can modulate blood glucose levels by enhancing β cell function and increasing insulin sensitivity. Animal studies have found the presence of Protopanaxadiol (PPD) and Protopanaxatriol-Type (PPT) ginsenosides act as anti-diabetic components. Ginseng is also capable of increasing glucose uptake through the enhancement of glucose transporter (GLUT) expression. Ginsenosides Rg1 and Re increase GLUT4 expression through the Adenosine monophosphate-activated protein kinase (AMPK) pathway in C2Cl2 muscle cells and through the enhancement of PPAR-γ activity in 3T3-L1 cells. The administration of ginseng can also suppress oxidative stress through the enhancement of antioxidant activity and the reduction of free radical levels. Insulin resistance can also be suppressed by ginseng by modulating inflammation.[6] But, Bessell *et al*.[7] found no discernible changes in these metrics between hydrolysed ginseng extract (HGE) and placebo-treated subjects. The level of glucose intolerance may explain the discrepancy between these results. HGE may have a higher impact on those with greater dysglycemia.[7]

Tang-Yi-Ping (TYP)
TYP is a combination of *Astragalus membranaceus*, *Rhizoma Dioscoreae*, *Atractylodes Lancea*, *Radix Bupleuri*, *Radix Paeoniae*

Alba, *Rhizoma Coptidis*, *Eupatorium fortune Turcz*, *Radix Scrophulariae*, *Puerarialobata*, and *Ramulus Euonymi*. It can treat IGT effectively and safely, improve pancreatic *β*-cell proliferation, and protect *β*-cell number and function. Li *et al*.[8] found that TYP controls the expression of 16 protein targets in the rat pancreas (PPif, Slc6a9, Cyp51, Rab3d, Man2b1, C7, Tmem181, Chmp4c, Rbp4, Fam3b, Flot2, Macroh2a1, Azgp1, Smn1, Ambp, and Mink1). Based on their data, they determined that these 16 proteins are the specific therapeutic targets that are aberrant after IGT development and tend to return to normal following TYP management.[8]

Jinlida granules

Jinlida is a Chinese herbal medicine approved by the Chinese Food and Drug Administration and clinically used in China as an anti-diabetic agent. Jinlida is a herbal formula that nourishes the Pi (spleen) and regulates the body fluids of diabetic patients. According to traditional Chinese medicine theory, Pi (spleen) deficiency is involved in the pathogenesis of type 2 diabetes.[9] Jinlida consists of seventeen Chinese medicinal herbs. Several components of Jinlida granules, such as ginsenosides, puerarin, and *C. chinensis*, have been proven to have hypoglycemic effects. A significant decrease in insulin resistance was also found after the administration of Jinlida. As many as 43.8% of prediabetes patients who received Jinlida therapy successfully returned to normal blood glucose levels, and only 6.2% progressed to diabetes mellitus. There are no side effects that indicate that Jinlida is not safe to use.[10] Jinlida can improve insulin resistance by upregulating the insulin signalling pathway and reducing skeletal muscle lipid content. Jinlida can also protect pancreatic *β* cells from palmitic acid-induced injury by activating AMPK.[11]

Allium hookeri (garlic).

Allium hookeri is a plant from the *Allium* genus, which includes onions, scallions, garlic, and chives, and contains specific amino acids such as S-Allyl-l-cysteinsulfoxide (ACSO), alliin, cycloalliin, and natural saponin compounds. It has been reported that sulfur-containing compounds from allicin and alkyl thiosulphinate in *Allium hookeri* have various physiological activities, such as lowering blood sugar and adipogenesis in diabetes models.[12] In addition, *Allium hookeri* has highly beneficial properties as an antifungal, anti-ulcer, anti-obesity, hepatoprotective, neuroprotective, hypolipidemic, and anti-inflammatory agent, as reported in various *in vitro* and *in vivo* experimental animals, including clinical trials.[13] The clinical trial found that supplementation with *Allium hookeri* extract twice daily for 8 weeks in prediabetic patients could lower HbA1C levels. Additionally, there is a significant difference in blood glucose levels 1 hour after the oral glucose tolerance test compared to the placebo group. There are no side effects related to the administration of *Allium hookeri extract*. This indicates that the supplementation of *Allium hookeri* extract can be well tolerated by patients.[14]

Nisha-Amalaki capsules

Nisha-Amalaki capsule is a combination of two Indian herbal plants, namely Nisha/turmeric (*Curcuma longa*) and Amalaki (*Emblica officinalis*). Turmeric is a rhizome medicinal plant with a long history of use in Asian countries, such as China and Southeast Asia. The primary natural polyphenol in *C. longa* and other *Curcuma* species is curcumin.[15] Curcumin has many health benefits. Curcumin has been proven beneficial for inflammatory conditions, metabolic syndrome, pain, and kidney health. The main advantages of curcumin are its anti-inflammatory and antioxidant properties.[16] Amalaki (*E. officinalis*), or Indian gooseberry, which belongs to the *Euphorbiaceae* family, plays an essential role in the traditional Indian medicinal system. Amalaki has traditionally been used to treat various diseases, such as rheumatic pain, asthma, nausea, constipation, intestinal diseases, heart conditions, and even cancer. Amalaki has hypoglycemic, anti-inflammatory, antihyperglycemic, and antioxidant properties, as shown in studies on animals and humans. These properties can be attributed to the amla fruit, rich in vitamin C, tannins, polyphenols, fibre, minerals, protein, and amino acids.[17] Nisha-Amalaki capsules in prediabetic patients for 180 days yielded positive results. The formulation has antihyperglycemic effects with insulin-sensitising effects. Patients receiving it also showed a significant decrease in several laboratory parameters related to diabetes: fasting blood glucose levels, blood glucose levels 2 hours after OGTT, HbA1C, and insulin levels.[18] The anti-diabetic properties of Amalaki have been linked to its content of ellagic acid, which stimulates pancreatic cells to release insulin and gallic acid,[19] which has been shown to upregulate the pAkt, PPAR-g and GLUT4 pathways, thereby increasing insulin sensitivity.[20] Both plants have been proven to have antioxidant and anti-inflammatory properties, reducing oxidative stress markers and CRP levels.[18]

Trigonella foenum-graceum (fenugreek).

Trigonella foenum-graecum has been used as a medicinal plant in Central Asia since around 4000 BC. This plant contains abundant active compounds, including galactomannan, saponins, diosgenin, and 4-hydroxyisoleucine, which have therapeutic properties for humans and animals. The content can produce several pharmacological effects, such as hypoglycemic effects, hypocholesterolemic effects, immunomodulatory effects, antimicrobial activity, anticancer effects, antioxidant effects, hormonal effects, hepatoprotective effects, and neuroprotective effects.[21] Research by Pickering *et al*.[23], which tested the efficacy of *Trigonella foenum-graecum* seed extract on prediabetic patients, found that the administration of 500 mg of extract per day was associated with significant positive effects on fasting and postprandial blood glucose levels. Furthermore, patients who consumed *T. foenum-graceum* extract maintained their triglyceride levels, but the placebo group experienced an increase in triglyceride levels during the 12-week study, indicating that the condition progressed in untreated prediabetic patients. However, in this study, no reduction in HbA1c levels was found. There are no clinical side effects or changes in kidney, liver, or metabolic markers using fenugreek.[22] The benefits of *T. foenum-graceum* seeds and seed extracts on glucose metabolism and insulin sensitivity have been linked to several constituents, including fibre, trigonelline, 4-hydroxyisoleucine (4-HIL), and saponins.[23] Previous clinical studies also found that 4-HIL produced insulin secretion effects by stimulating pancreatic beta cells. In animal studies, saponins in T. foenum-graceum seeds have been proven to lower fasting and postprandial blood glucose levels, insulin resistance and insulin markers, IL-6, TNF-*α*, increase GLUT-4 expression in skeletal muscles and significantly enhance pancreatic beta cell function.[22]

Moringa oleifera nanoparticles (MoNP).

Moringa oleifera is a natural medicine with a high concentration of flavonoids. *M. oleifera*'s principal flavonoids are quercetin, kaempferol, apigenin, luteolin, and myricetin glycosides. *M. oleifera* mainly includes quercetin (43.75%), with a total phenolic content in its methanol extract ranging from 71.08 ± 12.05 to 76.63 ± 10.63 mg GAE/g, 22% higher than spinach. *M. oleifera* is thus an excellent source of phytochemicals. Various treatments have been tested to determine the efficacy of *M. oleifera* in glycemic control. Animal studies indicate that *M. oleifera* can enhance glycemic control by regulating hyperinsulinemia, PPARγ, and inflammatory cytokines. Rusminingsih *et al*.[25] found that providing MoNP at 75, 150, and 225 mg/kg bw reduced fasting blood glucose. *M. oleifera's* hypoglycemic impact is mainly attributed to three types of phytochemicals: phenolic acids (chlorogenic acid), flavonoids (quercetin and kaempferol), and glucosinolates, which have antioxidant qualities. Quercetin and terpenoids increase the activity of glucokinase enzymes and pancreatic *β*-cells, lowering insulin resistance. Isothiocyanate inhibits gluconeogenesis, glycogenolysis in the liver, and glucose absorption into adipose tissue and muscle. Furthermore, *M. oleifera* reduces insulin resistance in muscle by activating the glucose transporter type 4 (GLUT-4) via an increase in the Akt signalling pathway. *M. oleifera* enhances fatty acid oxidation via AMP-activated protein kinase (AMPK) and PPAR-α pathways while inhibiting triacylglycerol and cholesterol synthesis through SREBP-1 regulation.[24,25]

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Table 2: Inclusion Articles of this study.

No.	Author, Year, Country	Study Objectives	Sample	Study Design	Study Duration	Result of the Study	Conclusion
1.	Erica Bessell, Nicholas R Fuller, Tania P Markovic, Namson S Lau, Jessica Burk, Chelsea Hendy, Tegan Picone, Ang Li, Ian D Caterson. -Year: 2020 -Australia	Assessing the efficacy of hydrolysed ginseng for glycemic control in people with prediabetes	401 samples were randomised and divided into 4 groups: *α-Cyclodextrin* + hydrolysed ginseng extract (HGE) group, aCD + placebo, HGE + placebo, and placeb0 + placebo group.	RCT	6 month	At six months, there were no discernible changes in these metrics between HGE and placebo-treated subjects (FPG of the HEG group is 96 mg/dl and placebo group is also 96 mg/dl, p-value 0.95. HbA1c of the HEG group is 5.5 mg/dl and placebo group is also 5.5 mg/dl, p-value 0.22).	Those with higher levels of dysglycemia might be affected by HGE.
2.	Jie Li, Shuai Bu, Honglei Zhou, Siling Bi, Yunsheng Xu. -Year: 2021 -China	Identifying potential therapeutic protein targets of a Tang-Yi-Ping (TYP) for treating impaired glucose tolerance (IGT) in rats.	19 samples. There are two groups: the TYP group (intervention group) and the IGT model group (control group).	RCT	8 weeks	After 8 weeks, TYP controls the expression of 16 protein targets in the rat pancreas (PPif, Slc6a9, Cyp51, Rab3d, Man2b1, C7, Tmem181, Chmp4c, Rbp4, Fam3b, Flot2, Macroh2a1, Azgp1, Smn1, Ambp, and Mink1). Our data shows that these 16 proteins are the specific therapeutic targets that are aberrant after IGT development and tend to return to normal following TYP management.	TYP can successfully reduce blood glucose levels and enhance islet shape in IGT rats.
3.	Ya-Lin Shi, Wen-Juan Liu, Xiao-Fang Zhang, Wei-Juan Su, Ning-Ning Chen, Shu-Hua Lu, Li-Ying Wang, Xiu-Lin Shi, Zhi-Bin Li, Shu-Yu Yang -Year: 2016 -China	Evaluating the efficacy of Jinlida granules (JLD), a Chinese herbal prescription, in the treatment of impaired glucose tolerance and its impact on the prevention of DM	65 samples were randomised and divided into 2 groups: the intervention group (receiving JLD granules) and the control group. (placebo)	RCT	12 weeks	The group receiving Jinlida showed a significant decrease in HbA1c ($p < 0.001$) and G2PP ($p = 0.037$) after 12 weeks compared to the control group. The insulin resistance index (HOMA-IR) significantly decreased in the Jinlida group ($p = 0.015$) and significantly increased in the control group. After 12 weeks, 14 patients (43.8%) in the Jinlida group returned to normal glucose levels, whereas only 2 patients (6.9%) in the control group returned to normal glucose levels. 2 patients (6.2%) in the Jinlida group developed DM compared to 5 patients (17.2%) in the control group. Both groups ' side effects on liver and kidney function were monitored within normal limits. 1 patient in the Jinlida group experienced diarrhoea. No patients suffered from hypoglycemia or severe side effects.	Granul Jinlida effectively improves glucose regulation, enhances the conversion of IGT to normal glucose, and improves insulin resistance in individuals with IGT.
4.	Soo-Hyun Park, Ui-Jin Bae, Eun- Kyung Choi, Su-Jin Jung, Sung-Hyen Lee, Jae-Heon Yang, You-Suk Kim, Do-Youn Jeong, Hyun- Ju Kim, Byung-Hyun Park, dan Soo- Wan Chae. -Year: 2020 -China	Evaluating the anti-diabetic effects of hookeri extract on subjects with prediabetes.	30 prediabetes samples were randomised and divided into the AHE group (15 people, 486 mg/day) and the placebo group. (15 orang)	RCT	20 weeks	After 8 weeks of AHE supplementation, HbA1c levels decreased significantly ($p = 0.012$) compared to the placebo group. Additionally, there were significant differences in plasma glucose levels 1 hour after the oral glucose tolerance test (OGTT) and the incremental area under the curve (iAUC) between the AHE and placebo groups.	8 weeks after AHE supplementation, plasma glucose levels during OGTT, iAUC, and HbA1c significantly decreased in the AHE group compared to the placebo group.

5.	Renuka Munshi, Shilpa Karande-Patil, Dipti Kumbhar, Amol Deshmukh, and Lal Hingorani, -Year: 2022 -India	Identifying the effectiveness of Nisha-Amalaki capsules in preventing the progression of prediabetes to diabetes mellitus.	62 samples were divided into 2 groups: the intervention group (receiving Nisha-Amalaki tablets) and the control group. (placebo)	RCT	6 months	The intervention group showed significant improvement in 2 risk factor scores from the IDRS (Indian Diabetes Risk Score): waist circumference and physical inactivity. In addition, a significant decrease was also found in BMI, fasting blood sugar levels 2 hours after OGTT, fasting insulin levels and 2 hours after OGTT, HbA1c, HOMA-IR, and oxidative stress markers after 6 months of Nisha-Amalaki tablet administration. Insulin resistance also improved in the intervention group. Ayurvedic symptom scores and quality of life scores also improved in the intervention group.	Treatment with Nisha-Amalaki capsules for 6 months improved clinical status and laboratory parameters, including insulin sensitivity, compared to placebo in prediabetic patients.
6.	Emily Pickering, Elizabeth Steels, Amanda Rao, Kathryn J. Steadman, -Year: 2022 -Australia	Assessing the safety and efficacy of *Trigonella foenum-graceum L.* seed extract to support healthy blood glucose metabolism in pre-diabetic patients	45 samples were randomised and divided into 2 groups: the intervention group (500 mg/day of T. foenum-graecum seed extract) and the control group. (placebo)	RCT	12 weeks	There was a significant difference in fasting blood glucose levels in the intervention group compared to the control group after 12 weeks ($p<0.001$). There was a significant decrease in 2-hour postprandial blood glucose levels compared to baseline in the intervention group. The HbA1C levels between the two groups do not differ significantly. The insulin levels during fasting or 1 and 2 hours postprandial did not differ between the two groups. No side effects were reported in the intervention group.	The extract of T. foenum-graceum seeds can be an effective treatment for fasting glucose and glucose tolerance disorders, both related to prediabetes.
7.	Esmi Rusminingsih, Hardhono Susanto, Diana N. Afifah, Ronny Martien, Hertanto Wahyu Subagyo. -Year: 2023 -Indonesia	Investigating the effect of *Moringa oleifera* nanoparticles (MoNP) supplementation based on the Self Nano Emulsifying Drug Delivery System on insulin resistance in prediabetes models.	25 samples were divided into 5 groups: Group I (Prediabetes rats, given 75 mg/kgbw MoNP 75, group II (Prediabetes rats, given 150 mg/kgbw MoNP 150, group III (Prediabetes rats, given 225 mg/kgbw MoNP 225, group IV (Normal control rats were given standard food, group V (Prediabetes control rats were given standard food).		4 weeks	MoNP significantly lowers TNF-α, IL-6, triglyceride, and HOMA-IR levels ($p<0.05$). It significantly increased insulin levels compared to the prediabetic control group ($p<0.05$). Supplementing with MoNP at 75 mg/kg body weight reduced FBS levels from 130.04 mg/dL to 97.34 mg/dL and HOMA-IR from 4.20 to 3.71 ($p < 0.05$).	MoNP treatment has lowered inflammatory cytokines and insulin resistance in prediabetic animals.

Footnotes: RCT: Randomized controlled trials.

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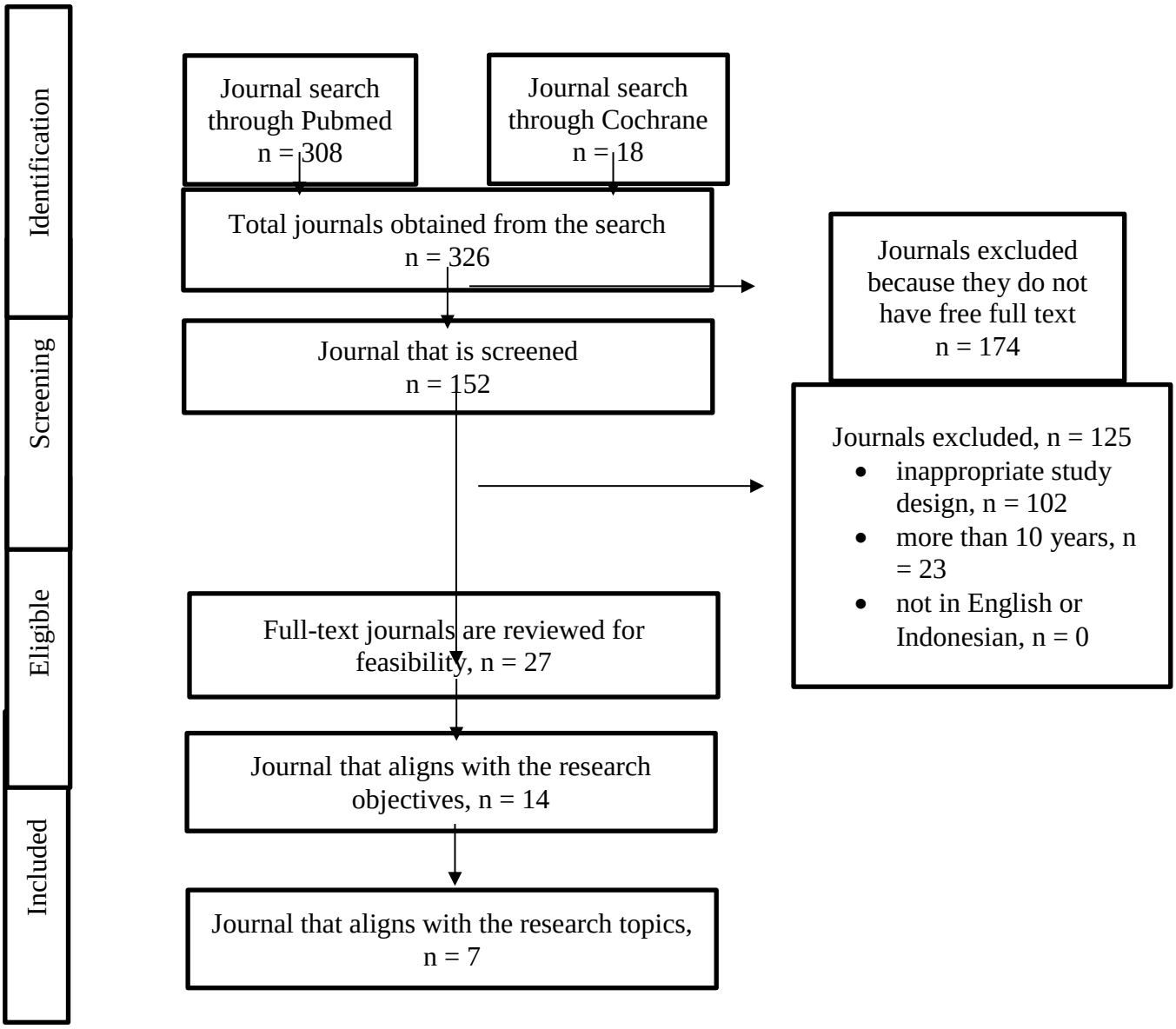

Figure 1: PRISMA Diagram (Journal articles inclusion flow chart).

Conclusion

Based on a systematic review of 7 randomised controlled trial articles on using herbal medicine in prediabetic patients, several herbal medicines have been studied and shown to have positive therapeutic effects and are safe to use. These herbal medicines are *Panax ginseng* Meyer (Ginseng), Tang-Yi-Ping, Jinlida granules, *Allium hookeri* (garlic), Nisha-Amalaki capsules, *Trigonella foenum-graceum*, and *Moringa oleifera* nanoparticles (MoNP). The efficacies of these herbal medicines were assessed based on their effectiveness in restoring clinical or laboratory parameters related to diabetes and its risk factors.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article are original and that any liability for claims relating to the content of this article will be borne by them.

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