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Review

The Effect of Giving Avocado Leaf and Seed Extract as Antidiabetes: A Systematic Literature Review

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Abstract: This literature review aimed to determine the effect of giving avocado leaf extract and seeds as an antidiabetic. The literature study was conducted by choosing an experimental research design using experimental animal subjects. The results of a review of 9 articles showed that avocado seed and leaf extract as antidiabetics were that both of them showed potential as promising antidiabetic agents. Research on avocado seed extract showed that administration of avocado seed extract positively improved glycemic control and reduced diabetes symptoms in diabetic rats. On the other hand, research on avocado leaf extract showed that administration of avocado leaf extract could also reduce blood glucose levels and regulate lipid profiles in diabetic rats. These two extracts show different but consistent effects in improving blood glucose regulation and lipid profiles in diabetic conditions. Avocado seed extract showed a more significant effect in reducing diabetes symptoms, while avocado leaf extract showed promising potential in regulating blood glucose levels and lipid profiles.

Keywords: Avocado Leaf, Avocado Seed, Antidiabetes, Blood Glucose.

1. Introduction

Diabetes mellitus, especially type 2 diabetes, is a chronic disease and public health problem whose prevalence continues to increase globally and significantly impacts life and high medical costs (Khan et al., 2020). According to a report from the World Health Organization (WHO), between 2000 and 2019, there was a 3% increase in the age-standard death rate attributable to diabetes. In lower-middle-income countries, there has been a 13% increase in the death rate from diabetes (WHO, 2023).

Appropriate and effective management of diabetes is becoming increasingly important to reduce long-term complications and improve the quality of life of sufferers (Fithria et al., 2022; Zimmerman & Pantalone, 2014). In addition to conventional therapy, research on using natural ingredients as antidiabetic agents is increasingly attracting attention to find alternative therapies that can potentially provide health benefits.

Avocado fruit is rich in nutrition with high levels of vitamins, minerals, protein, and fiber and contains high concentrations of unsaturated fatty acids, which play an important role in maintaining health (Yahia et al., 2019). In addition, avocado peels and seeds contain a variety of bioactive phytochemical compounds such as phenolic acids, condensed tannins, and flavonoids, including procyanidins, flavonols, hydroxybenzoic and hydroxycinnamic acids, which provide additional health benefits (Figueroa et al., 2018; Hurtado-Fernández et al., 2011). Previous studies have shown that these components may increase insulin sensitivity, reduce insulin resistance, and suppress the activity of enzymes involved in glucose metabolism (Martín & Ramos, 2021).

Although several studies have supported the antidiabetic effects of avocado leaf and seed extracts, the existing literature still requires a more comprehensive synthesis and analysis. Therefore, a systematic literature review is important for collecting, compiling, and critically evaluating existing research results.

This article aims to present a summary of the results of a systematic review of the existing literature regarding the effect of giving avocado leaf and seed extract as an antidiabetic agent to provide a deeper understanding of the potential of this natural ingredient as a potential complementary therapy in the management of diabetes mellitus.

2. Method

This study used the Systematic Literature Review method to summarize evidence regarding the potential of avocado leaf and seed extract as an antidiabetic agent, conducted in April and May 2023. In the early stages of the study, research questions were identified consisting of PICO (Population, Intervention, Comparator, and Outcome). The population was experimental animals (mice), the intervention was leaf extract and avocado seeds, not using a comparator, and the outcome was diabetes mellitus parameters. To get the appropriate data results, this stage began with a data search on the website http://www.scopus.com; https//www.mdpi.com/; https://pubmed.ncbi.nlm.nih.gov/; https://www.sciencedirect.com/. The keywords used were "Avocado Leaves AND Animal AND Diabetes Mellitus". The article inclusion criteria, namely the type of article was the result of research published in 2018 – 2023, the article was in English, the population was experimental animals (rats), administration of extracts from avocado seeds, leaves, and peels, and the outcome was in the form of diabetes mellitus parameters.

Followed by data screening to filter and select the appropriate data based on the journal abstract obtained and ends with an assessment of data quality using the website https://rayyan.ai/. The quality of the data was measured by the clarity of the research article methodology, which can provide a good chronological aspect starting from the selection of materials and study results that were in accordance with this article. The next step was to develop a protocol using meta-analysis (PRISMA/Preferred Reporting Hans for Systematic Reviews and Meta-analysis) (Moher et al., 2009). The data extraction process included full-text articles and summarized information by systematic review (Figure 1).

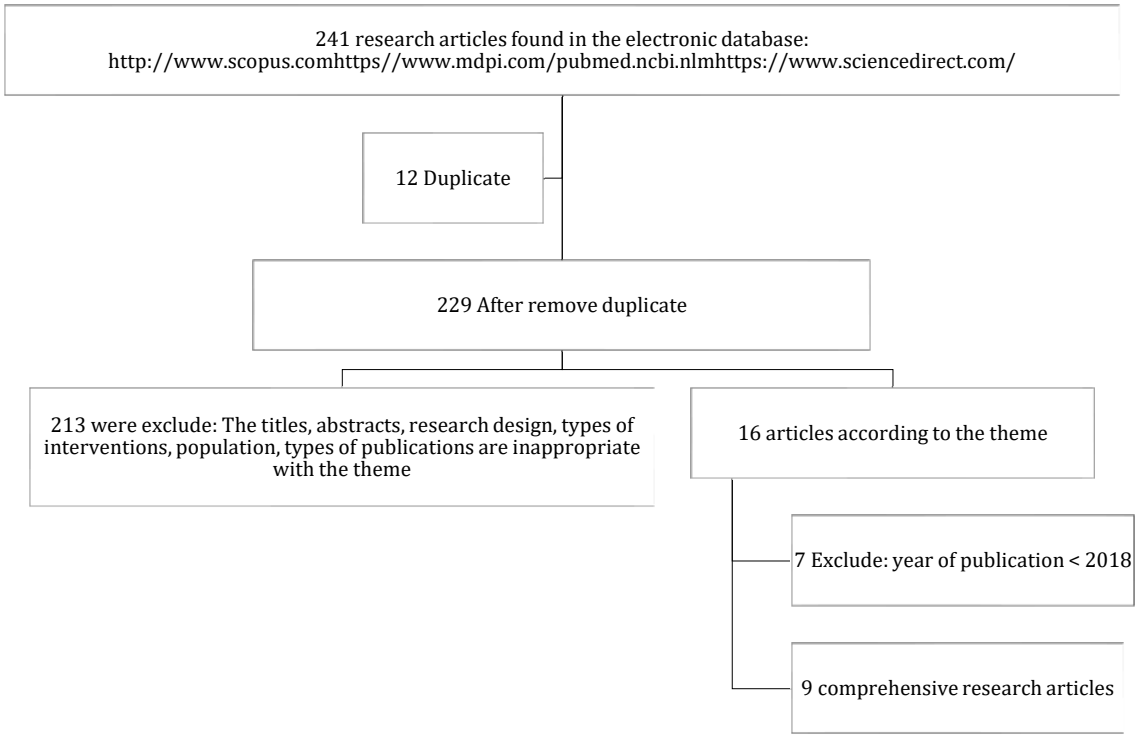

Figure 1. Flow diagram of research articles on the Effects of Giving Avocado Leaf and Seed Extract as Antidiabetes.

3. Results

Table 1 shows that of the 9 articles, there were 5 articles using avocado seed extract as an antidiabetic and 3 articles using avocado leaf extract, and 1 article using avocado peel as an antidiabetic. The 9 articles showed significant results regarding the role of avocado extract (seeds, leaves, skin) on diabetes mellitus parameters.

Table 1 Tabulation of Data Extraction

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
1	Effect of Avocado (*Persea Americana Mill.*) Peel Extract on the Diabetic Male White Rats: Preclinical Study (Rahman et al., 2022)	Peels	Experimental in vivo.	The duration of the intervention was 2 weeks. Intervention type: 1) Group 1 is only given food; 2) Group 2 was given feed + STZ + 10% sucrose + no avocado skin extract; 3) Group 3 was given feed + STZ + 10% sucrose + avocado peel extract at a dose of 100 ml/kg BW; 4) Group 4 was given feed + STZ + 10% sucrose + avocado skin extract at a dose of 200 ml/kg BW; 5) Group 5 was given feed + STZ + 10% sucrose + avocado peel extract at a dose of 400 ml/kg BW;	• Group 1 experienced a decrease in fasting blood glucose levels of 34 mg/dL (p=0.397) • Group 2 experienced a decrease in fasting blood glucose levels of 7.33 mg/dL (p=0.958 • Group 3 experienced a decrease in fasting blood glucose levels of 30.33 mg/dL (p=0.624) • Group 4 experienced a significant reduction in fasting blood glucose levels of 133.33 mg/dL compared to the other groups (p=0.003). • Group 5 experienced an increase in fasting blood glucose levels of 331 mg/dL (p=0.035)
2	Vascular effects of avocado seed glycosides during diabetes-induced endothelial damage (Amadi et al., 2020)	Seed	Experimental	The duration of the intervention was 4 weeks. Intervention type: 1) Group 1: non-diabetic control rats 2) Group 2: untreated diabetic rats 3) Group 3: diabetic rats treated with 5 mg/kg BW glibenclamide 4) Group 4: diabetic rats treated with 5 mg/kg BW metoprolol succinate (metsu) and losartan 5) Group 5: non-diabetic rats given ASG 200 mg/kg BW 6) Group 6: diabetic rats given ASG 200 mg/kg BW	1) Glucose homeostasis: • Group 2 has the highest blood glucose and glucagon levels • Group 3 has an increase in blood glucose levels comparable to Group 1 • The interventions in Group 4 and Group 6 showed the same effect in that they did not completely reverse the effect of streptozotocin on blood glucose and glucagon 2) Vascular dysfunction • Group 5 produced lower renin and angiotensin levels than Group 1. • Group 1 produced higher plasma renin activity and angiotensin levels while Group 3 produced a slight decreasing effect

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
					• Intervention in Group 4 and Group 6 resulted in normal plasma renin and angiotensin levels. • Intervention in Group 3 resulted in a slight decrease in VCAM-1 and Lp-PLA2 levels • Interventions in Group 4 and Group 6 resulted in VCAM-1 and Lp-PLA2 levels equivalent to Group 1. 3) Endothelial integrity • Intervention in Group 3 did not achieve reversal of changes in VWF, eNOx, and endothelin • Intervention in Group 4 and Group 6 resulted in levels of VWF, eNOx, endothelin and homocysteine equivalent to Group 1. 4) Heart integrity • Intervention in Group 3 resulted in CnT levels equivalent to Group 1. • Intervention in Group 4 significantly reduced crt-k and LDH levels. • Intervention in Group 6 resulted in crt-k and LDH levels equivalent to normal mice's. • Group 2 has increased TC, TG, and LDL levels. • Group 3 only experienced changes in HDL levels to normal. • Intervention in Group 4 and Group 6 can reverse the altered lipid profile. • The interventions in Group 3, Group 4, and Group 6 did not affect heart rate.
3	Antidiabetic activity of avocado seeds (*Persea americana Mill.*) in diabetic rats via activation of PI3K/AKT signaling pathway (Ojo et al., 2022)	Seed	Experimental	The duration of the intervention was 2 weeks. Intervention type: 1) Group 1: normal control 2) Group 2: diabetes control 3) Group 3: diabetics were given metformin 4) Group 4: diabetics were given AEPAS 26.7 mg/kg	• The decrease in fasting blood glucose levels in Group 5 and Group 6 is equivalent to Group 1. • There was a slight increase in body weight in Group 4, Group 5 and Group 6, depending on the dose. • In Group 2 there was a decrease in HOMA-β levels and an increase in HOMA-IR levels. • Intervention in Group 4, Group 5 and Group 6 resulted in increased serum insulin and HOMA-β levels and decreased HOMA-IR levels.

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
				5) Group 5: diabetics were given AEPAS 53.3 mg/kg 6) Group 6: diabetics were given AEPAS 106.6 mg/kg	• MDA levels increased in Group 2 and decreased in Group 3, Group 4, Group 5, and Group 6, depending on the dose. • GPx, GST, GSH, CAT, and SOD activity in the pancreas increased in Group 3, Group 4, Group 5, and Group 6. • Triglyceride, LDL-c, total cholesterol, CRI, VLDL-c, and AI levels decreased in Group 4, Group 5, and Group 6. • Group 3 produced significant reductions in triglyceride, LDL-c, total cholesterol, CRI, VLDL-c, and AI levels with corresponding HDL-c levels. • Levels of liver glycogen and glycolytic enzymes, hexokinase increased in Group 3, Group 4, Group 5 and Group 6. • The activity of gluconeogenesis enzymes G6Pase and F-1,6-BPase increased in Group 2, but decreased in Group 3, Group 4, Group 5 and Group 6. • IL-6, TNF-α, and NF-κB levels decreased in Group 4, Group 5 and Group 6 compared to Group 2 and Group 3. • PI3K and AKT mRNA expression levels in the liver increased in Group 3, Group 4, and Group 5. • Increased expression of PI3K, AKT, and Bcl-2 mRNA in the pancreas occurred in Group 3, Group 4, Group 5, and Group 6. • PCNA mRNA expression in the pancreas increased in Group 4 and Group 5 while decreased in Group 6. • Interventions in Group 4, Group 5 and Group 6 repair and restore damaged pancreatic cells.
4	Nephroprotective Potential of *Persea americana* (Avocado) Ethanol-Water Seed Extract and Glucovance in Streptozotocin-Induced Wistar Rats (Okputu et al., 2022)	Seed	Experimental	The duration of the intervention was 4 weeks. The types of interventions are: 1) Group A: normal control 2) Group B: diabetes control 3) Group C: diabetes group treated with 500 mg/kg Glucovance 4) Group D: diabetes group treated with 500 mg/kg of P. americana seed extract	• Serum bilirubin: There was a reduction in total bilirubin levels in the diabetic control group compared to normal controls • Serum creatinine: There was a decrease in serum creatinine concentrations in rats given *P. americana* seed extract compared to the control group. • Serum urea: There is an increased serum urea level in diabetic controls compared to normal controls.

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
				5) Group E: diabetes group treated with 250mg/kg of *P. americanana* seed extract and glucovance	• Serum chloride ions: There was a decrease in serum chloride ion concentrations in the avocado seed extract group in rats compared to the control group. • Serum sodium ions: The untreated diabetic group showed increased serum sodium ions compared to the normal control group. • Serum potassium ions: Serum potassium ions are higher in untreated diabetics than in normal controls. • Body weight of mice: There was an increase in body weight of mice treated with *P. americana* leaf extract compared to the untreated group depending on the dose given. • Hematologic profile: There were increased levels of PWD, RWD, MVP, and PVC in diabetic controls compared to normal controls. There was also an increase in HB in the group treated with glucovance 500mg/kg compared to the diabetes control group and the group treated with 500 mg/kg extract. Whereas RBC, HGB, HCT, PLT, and OCT showed a decrease in diabetic controls compared to normal controls.
5	The avocado (*Persea americana mill.*) leaf extract on streptozotocin-induced pancreatic cell regeneration of white rats (*Rattus norvegicus*) (Rahman et al., 2021)	Leaf	Experimental	Performed on 18 male white rats as subjects, divided into six groups of 3 rats each. 1) G1 : feed + STZ + 10% sucrose + 100 mg/kg bw extract + 0.5% NaCMC 2) G2 : feed + STZ + 10% sucrose + 150 mg/kg bw extract + 0.5% NaCMC 3) G3 : feed + STZ + 10% sucrose + 200 mg/kg bw extract + 0.5% NaCMC 4) G4 : feed + STZ + 10% sucrose + 0.5% NaCMC 5) G5 : feed + STZ + 10% sucrose + glibenclamide + 0.5% NaCMC 6) G6 : normal healthy animals + regular feed	• The results showed that pancreatic cell damage in experimental animals was G1 = 1.67 (moderate cell damage); G2 = 1.00 (light cell damage); G3 = 0.33 (no damage); G4 = 3.00 (severe cell damage); G5 = 0.33 (no damage); and G6 = 0.33 (no damage). • A dose of 100 mg/kg bw of avocado ethanolic extract had an impact on pancreatic cell regeneration in male white rats with a score of 1.67. However, the increase in pancreatic cell regeneration seems to increase in line with the dose, a score of 1.00 at a dose of 150 mg/kg bw and a score of 0.33 at a dose of 200 mg/kg. A score of 0.33 was also seen in G5 (receiving glibenclamide) and G6 in normal healthy animals). However, the most damage was in G4 which was obtained only 0.5% Na-CMC
6	Comparative Antidiabetic Activity of Aqueous,	Leaf	Experimental	The duration of the intervention was 4 weeks.	• Incidence of treatment on glycemia: Prior to treatment, all diabetic rats had hyperglycemia. One week after

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
	Ethanol, and Methanol Leaf Extracts of *Persea americana* and Their Effectiveness in Type 2 Diabetic Rats (Kouamé et al., 2019)			Mice were grouped into 6 random subgroups consisting of 5-7 rats per group. 1) NDC group (n=5): nondiabetic control (NDC) who only received vehicles (10 ml/kg/day, body weight) 2) DC group (n=6): diabetes control (DC) who only received vehicle (10 ml/kg/day, body weight) 3) GLIB group (n=6): diabetic rats treated with glibenclamide (GLIB; 10 mg/kg/day, b.w.) 4) AE group (n=7): diabetic rats treated with aqueous extract (AE; 100 mg/kg/day, bw) 5) EE group (n=7): diabetic rats treated with ethanolic extract (EE; 100 mg/kg/day, bw) 6) ME group (n=7): diabetic rats treated with methanol extract (ME; 100 mg/kg/day, bw)	starting treatment, the mean serum glucose of the group treated daily with *P. americana* AE, EE, and ME at a dose of 100 mg/kg was reduced compared to baseline. At the end of the treatment period ie, 28 days. The extract brought about a significant decrease in glycemia for AE, EE, and ME. These results prove that the three extracts have managed type 2 diabetes in rats. • Effect of treatment on the condition of the rats: all diabetic rats treated with AE, EE, and ME at a daily dose of 100 mg/kg showed an increase in body weight, whereas the body weight of the DC and GLIB groups remained the same. Although the weight gain of the treated mice was significantly superior to that of the DC group (non-treated), it was significantly lower than the mean of normoglycemic mice (NDC group). • Organ-to-body weight ratio: The kidney-to-body weight ratio of T2DM mice from the DC and GLIB groups was significantly ($p < 0.01$) higher than that of the normoglycemic (NDC) animals. In addition, the liver-to-body weight ratio increased significantly for the glibenclamide-treated group. • Lipid profile: AE, EE, and ME at 100 mg/kg/day restored the T-CHOL and HDL-C portions at levels comparable to the NDC group (0.70 g/L and 0.28 g/L). However, the TG, VLDL-C, and T-LIP levels were slightly below the normal values of the NDC group. LDL-C and AIP were lower in the extract-treated group compared to the untreated diabetes (DC) group. • Blood ionogram parameters: The blood ionogram showed, in general, that the proportions of Na^+ , Cl^- , and Ca^{2+} were not significantly different after the 28 day treatment period. Meanwhile, the K^+ value decreased by 13.5% in the EE group about the control group (DC). • Histopathological analysis: the NDC rat group showed multiple islets of Langerhans with normal architecture. However, islet cells in diabetic mice

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
					treated with AE, EE, and ME for 28 days partially recovered. Kidney tissue showed a normal appearance and liver tissue showed hepatic lobules with regular and normal liver cells. • Intestinal absorption of glucose: There was a depletion of intestinal glucose in normoglycemic rats with prior administration of AE, EE, and ME (30 minutes) at a dose of 100 mg/kg
7	*Persea americana* seeds improve glycosylation and dyslipidemia in fructose-fed streptozotocin-injected type 2 diabetic male rats (Mudassir et al., 2020)	Seed	Experimental *in vivo*	The duration of the intervention was 2 weeks. Control group: Given a standard diet of distilled water Diabetes group: Given 35% fructose for 6 weeks, followed by STZ 40 mg/kg bw injection. Then the Diabetes group is divided into: 1) Control diabetes 2) The positive control was given Pioglitazone 15 mg Zolid/kg bw 3) The test group was given CSSPa 500 mg/kg	• Decreased lipid profile ($p < 0.01$) and increased HDL ($p < 0.01$). • Serum ALT, CK, uric acid, bilirubin, and fasting blood glucose were significantly increased ($p < 0.01$). • Increases in cardiac risk index, fasting insulin resistance index, percentage glycemic change, and HbA1c ($p < 0.01$).
8	The dosage of the avocado leaf extract (*Persea americana mill.*) on regeneration of diabetic white rats (*Rattus norvegicus*) renal cell (Rahman et al., 2020)	Leaf	Experimental	3 male white rats per group: 1) Group 1: fed + STZ + 10% sucrose + 100 mg/kg bw of avocado leaf extract + 0.5% NaCMC 2) Group 2: fed + STZ + 10% sucrose + 150 mg/kg bw of avocado leaf extract + 0.5% NaCMC 3) Group 3: fed + STZ + 10% sucrose + 200 mg/kg bw of avocado leaf extract + 0.5% NaCMC	Average rat kidney damage: G1 (1.67), G2 (1.33), G3 (0), G4 (3), G5 (0), G6 (0). Giving a dose of 100 mg/kg bw of avocado leaf extract did not affect the regeneration of kidney tissue in male white rats (1.67), but the average score of kidney damage was reduced to 1.33 at a dose of 150 mg/kg bw of avocado leaf extract. At a 200 mg/kg bw dose of avocado leaf extract, the average kidney damage score was 0, the same as group 5, which was given Glibenclamide.

No	Research Title and Author	Avocado Parts	Research design	Time Duration (weeks) and intervention	Results
				4) Group 4: fed + STZ + 10% sucrose + 0.5% NaCMC 5) Group 5: fed + STZ + 10% sucrose + Glibenclamide + 0.5% NaCMC 6) Group 6: fed only	
9	The effect of protein fractions of avocado (*Persea Americana*) on biochemical parameters in a diabetic rat model (Aljawadi, 2020)	Seed	Experimental	1) Group 1: given normal treatment. 2) Group 2: given IP injection of alloxan 125 mg/kg. Each group was divided into 8 subgroups (4 rats/subgroup), the first subgroup was the control group and the rest were given IP injections of crude water extract and protein fractions at doses of 50, 75, 100 and 125 mg/kg body weight.	• Compared to oral administration, decreased glucose levels due to IP injection of protein fraction (B) and concentrated aqueous extract. • The molecular mass of the separated active protein fraction (peak B) is 24,000 daltons. • Decreased fasting blood glucose levels, total serum lipids, and cholesterol levels in normal rats given crude water extract and protein fraction 75 mg/kg bw. • At the same dose (75 mg/kg bw), decreased serum glucose levels, serum total lipids, and cholesterol levels in diabetic rats.

4. Discussion

Avocado Seed Extract and Antidiabetic

The effect of avocado seed extract as an antidiabetic agent has been a concern in several studies. The results of the study show that avocado seed extract can have a positive effect on regulating blood glucose levels in diabetics. Avocado seed extract contains bioactive compounds, such as flavonoids, phenolics, and unsaturated fatty acids, which are believed to have the potential to increase insulin sensitivity, slow down glucose absorption in the intestine, and increase glucose metabolism in body tissues. Several preclinical studies on diabetic rats showed that administration of avocado seed extract consistently reduced blood glucose levels, increased glucose tolerance, and decreased insulin resistance. In addition, avocado seed extract has also been shown to positively affect lipid profiles by lowering triglyceride and total cholesterol levels and increasing HDL cholesterol levels which are good for heart health.

The results of a study conducted by Amadi, Agomuo, and Adumekwe (2020) on the effects of avocado seed glycosides on endothelial damage caused by diabetes showed that avocado seed glycosides have potentially beneficial effects in reducing vascular dysfunction and restoring endothelial and cardiac integrity in rats with diabetes-induced endothelial damage (Amadi et al., 2020). However, more research and clinical trials in humans are needed to understand the effects of avocado seed glycosides and confirm their therapeutic potential in diabetes-associated endothelial damage.

Overall, the results of research conducted by Ojo et al. (2022) showed that avocado seed has the potential as an antidiabetic agent with various positive effects on glucose regulation, pancreatic beta cell function, lipid profile, oxidative stress, and inflammation through activation of the PI3K/AKT signaling pathway and antioxidant effects (Ojo et al., 2022). Although this study was conducted in mice, the results could form an interesting basis for further testing in humans and could provide a potential guide for developing natural therapies for diabetes. The results of research conducted by Okputu et al. (2022) demonstrated the nephroprotective potential of avocado seed extract in reducing kidney damage in diabetic rats and some effects on hematological and electrolyte parameters (Okputu et al., 2022).

The results of research conducted by Mudassir et al. (2020) showed that giving avocado seeds positively reduced unhealthy lipid profiles and increased HDL levels in type 2 diabetes rats. However, the results also showed impaired liver function, muscle damage, and problems with glucose and uric acid metabolism in the mouse (Mudassir et al., 2020). Therefore, further research is needed to understand the mechanism of action of avocado seeds and their impact on humans with type 2 diabetes. The results of research conducted by Aljawadi (2020) showed that the protein fraction of avocado fruit could potentially reduce blood glucose levels, total serum lipids, and cholesterol levels in normal and diabetic mice. These findings can form the basis for further understanding the potential of avocado fruit as a potential ingredient for treating or managing diabetes and health problems related to lipid metabolism (Aljawadi, 2020).

Although preclinical research shows promising results, it is important to remember that the effects of avocado seed extract in humans still need to be verified through more clinical studies. Furthermore, the mechanism of action and the exact dosage of avocado seed extract must be explained further. Nonetheless, the findings from this preclinical study provide hope that avocado seed extract can be a potential natural source for the treatment and management of diabetes and opens the door for further research in the development of antidiabetic therapies based on natural ingredients.

Avocado Fruit Peel Extract and Antidiabetic

The effect of avocado peel extract as an antidiabetic agent has also become an interesting research subject. Several preclinical studies have evaluated the potential of avocado peel extract in regulating blood glucose levels in diabetics. The results showed that avocado peel extract contains bioactive compounds such as flavonoids, phenolic acids, and proanthocyanidins, which can increase insulin sensitivity and reduce insulin resistance in body cells. Research in animal models of diabetes shows that the administration of avocado peel extract can significantly reduce blood glucose levels, improve glucose tolerance, and decrease inflammation associated with diabetes. In addition, avocado peel extract has also been shown to positively affect lipid profiles by lowering triglyceride and total cholesterol levels and increasing HDL cholesterol levels, which are beneficial for heart health.

The research results of Rahman et al. (2022) regarding the effect of avocado peel extract on male white rats with diabetes showed differences in response to fasting blood glucose levels between the treatment groups (Rahman et al., 2022). The results showed that avocado peel extract at certain doses did not significantly reduce fasting blood glucose levels in several treatment groups. However, a certain group (Group 4) showed a significant decrease in fasting blood glucose levels after administration of avocado peel extract. On the other hand, a group (Group 5) experienced a significant increase in fasting blood glucose levels after administering avocado peel extract. The effect of avocado peel extract on fasting blood glucose levels can vary depending on the dose given and the characteristics of each group. The group that showed a decrease in fasting blood glucose levels shows the potential of avocado peel extract as an antidiabetic agent to reduce blood glucose levels (Rahman et al., 2022). However, further research is needed in the group experiencing elevated fasting blood glucose levels to understand the mechanisms and factors contributing to these different effects.

Follow-up research conducted by Rahman et al. (2020) showed that avocado leaf extract has the potential to increase kidney cell regeneration in male white rats with diabetes (Rahman et al., 2022). The results showed that the dose of avocado leaf extract affected the level of kidney damage, where the higher the dose of the extract given, the lower the level of kidney damage that occurred. The 200 mg/kg bw dose of avocado leaf extract showed the most positive results with no detectable signs of kidney damage (Rahman et al., 2022).

Research conducted by Kouamé et al. (2019) found that avocado leaf extract (*Persea americana*) had a significant antidiabetic effect on type 2 diabetic rats. The use of aqueous extract (AE), ethanolic extract (EE), and methanol extract (ME) of avocado leaves at a dose of 100 mg/kg /day succeeded in lowering blood glucose levels in diabetic rats, and the three extracts helped regulate type 2 diabetes in rats over a 28-day treatment period (Kouamé et al., 2019). This study found that administration of avocado leaf extract at a dose of 100 mg/kg/day did not cause an excessive increase in body weight in rats, but the increase in body weight was lower than in normoglycemic rats (NDC group). In addition, avocado leaf extract also managed to regulate the lipid profile of diabetic rats by returning total cholesterol (T-CHOL) and high-density lipoprotein cholesterol (HDL-C) levels to normal levels while lowering triglyceride (TG) levels, very low-density lipoprotein cholesterol (VLDL-C), and total lipoprotein (T-LIP), as well as low-density lipoprotein cholesterol (LDL-C) and atherogenic index of plasma (AIP) (Kouamé et al., 2019).

This study also showed that administration of avocado leaf extract positively affected important organs, such as the kidney and liver, by increasing the ratio of kidney and liver to body weight in rats and repairing some damaged pancreatic islet cells in diabetic rats. In addition, the administration of avocado leaf extract also affected glucose absorption by the intestine in normoglycemic rats. Avocado leaf extract has the potential as an effective antidiabetic agent and positively impacts several health parameters of diabetic rats, including improvement of glycemic control, regulation of lipid profiles, and positive effects on vital organs. However, keep in mind that the results of research on mice are not

always directly applicable to humans, and further research is needed to understand the effects of avocado leaf extract on humans and its possible application as an alternative treatment for type 2 diabetes (Kouamé et al., 2019). However, more research and human clinical trials are needed to validate its effects and better understand its mechanism of action.

The results of other studies related to dose showed that a dose of 100 mg/kg of avocado ethanolic extract positively affected the regeneration of pancreatic cells in male white rats that had cell damage. Increasing the dose of avocado extract seems to increase the regenerative effect on the pancreas. However, the most severe cell damage was seen in the group that received 0.5% Na-CMC vehicle (Rahman et al., 2021). This suggests that avocado ethanolic extract can enhance pancreatic cell regeneration and be a potential candidate as a regenerative agent in conditions of pancreatic cell damage. However, remember that this study was conducted in mice, so the results must be verified and tested further in humans to understand its therapeutic potential better.

Although some findings point to the potential of avocado peel extract as a promising antidiabetic agent, it should be remembered that this research is still in its early stages and needs to be tested further through human clinical studies to validate its effectiveness and safety. In addition, the optimal mechanism of action and dosage also need to be studied further. With the results of this study, avocado peel extract can be a potential ingredient to be developed as a natural therapy to treat diabetes, which can help improve the quality of life for diabetics in the future.

Avocado seed and leaf extract as antidiabetic agents have the potential to regulate blood glucose levels and lipid profiles in diabetics. Research on avocado seed extract shows that its bioactive compounds can increase insulin sensitivity, slow down glucose absorption in the intestines, and increase glucose metabolism in body tissues. In addition, avocado seed extract has also been shown to positively affect lipid profiles by lowering triglyceride and total cholesterol levels and increasing HDL cholesterol levels which are good for heart health. On the other hand, research on avocado leaf extract shows that its bioactive compounds also have significant antidiabetic effects, with the ability to lower blood glucose levels and increase glucose tolerance in diabetic rats. In addition, avocado leaf extract has also been shown to impact important organs such as the kidneys and liver positively and can repair damaged pancreatic islet cells in diabetic rats.

Although the results of research on both avocado extracts show promising potential as antidiabetic agents, it should be remembered that these studies are still being conducted in animal models (rats) and have not been carried out in humans. Therefore, more human clinical studies are needed to validate further the antidiabetic effects of avocado seed and leaf extracts and to understand their mechanism of action in depth. In addition, it is important to determine the correct dosage and understand the long-term effects of using avocado extract as an antidiabetic therapy before recommending its use in humans.

The implications of the research results are that both avocado seed and leaf extracts show potential as effective antidiabetic agents. The research conducted using experimental animal subjects suggests that avocado seed extract has a significant impact on improving glycemic control and reducing diabetes symptoms in diabetic rats. On the other hand, avocado leaf extract also demonstrates the ability to lower blood glucose levels and regulate lipid profiles in diabetic rats. These findings are significant because they suggest that avocado, specifically its seed and leaf extracts, could be considered for further development as natural treatments or supplements for diabetes management. The distinct yet consistent effects observed in the two extracts highlight their different mechanisms of action in improving blood glucose regulation and lipid profiles in the context of diabetes. While avocado seed extract appears to have a stronger impact on reducing diabetes symptoms, avocado leaf extract holds promise in regulating blood glucose levels and lipid profiles.

5. Conclusion

The general conclusion from research on avocado seed and leaf extracts as antidiabetics is that both show potential as promising antidiabetic agents. Research on avocado seed extract showed that administration of avocado seed extract positively improved glycemic control and reduced diabetes symptoms in diabetic rats. On the other hand, research on avocado leaf extract showed that administration of avocado leaf extract could also reduce blood glucose levels and regulate lipid profiles in diabetic rats. These two extracts show different but consistent effects in improving blood glucose regulation and lipid profiles in diabetic conditions. Avocado seed extract showed a more significant effect in reducing diabetes symptoms, while avocado leaf extract showed promising potential in regulating blood glucose levels and lipid profiles.

While the research results are promising, it is important to remember that this study was conducted on experimental animals, so more clinical studies in humans are needed to verify and optimize the use of avocado seed and leaf extracts as part of antidiabetic therapy. In addition, it is also necessary to consider the dosage and potential side effects of using avocado extract in humans before it can be considered an effective and safe treatment for diabetes.

Referensi

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