CHAPTER 1
INTRODUCTION

1.1 Research Background

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disease caused by a persistent increase in blood glucose levels, which can damage blood vessels, nerves, kidneys, eyes, heart, and other organs[1]. The International Diabetes Federation (IDF) reported that approximately 537 million people worldwide had diabetes mellitus in 2021, and this number is projected to rise to 643 million by 2045. The countries with the highest number of adults aged 20-79 years with diabetes in 2021 were China, India, and Pakistan. Indonesia ranked fifth, with 19.5 million cases, which are expected to increase to 28.6 million by 2045[2]. According to the 2023 Indonesian Health Survey, the prevalence of T2DM in individuals aged ≥15 years based on blood glucose level measurements increased from 10.9% in 2018 to 11.7% in 2023[3].

The complications of T2DM are broadly classified into microvascular and macrovascular complications. Microvascular complications include neuropathy, nephropathy, and retinopathy, while macrovascular complications consist of cardiovascular disease, stroke, and peripheral artery disease. Among these, microvascular complications occur more frequently in T2DM patients than macrovascular complications[4].

One of the most common macrovascular complications is atherosclerotic cardiovascular disease (ASCVD), which is caused by lipid metabolism disorders, also known as dyslipidemia. ASCVD can be measured using a new parameter called the Atherogenic Index of Plasma (AIP), the ratio of

[1] World Health Organization, "Diabetes," 2023, https://www.who.int/health-topics/diabetes?gclid=CjwKCAiAvdCrBhBREiwAX6-6Ur6kEG6VzAu8ybajtUWVN4xX-nN3C5LY3PnWMulfIm9wzneQI_1DkhoC10oQAvD_BwE#tab=tab_1.

[2] International Diabetes Federation, *IDF Diabetes Atlas*, ed. Edward J Boyko et al., *Diabetes Research and Clinical Practice*, 10th ed., vol. 102 (International Diabetes Federation, 2021), https://doi.org/10.1016/j.diabres.2013.10.013.

[3] Kemenkes RI, "Prevalensi, Dampak, Serta Upaya Pengendalian Hipertensi & Diabetes Di Indonesia," *SKI*, 2023, 1–3, https://www.badankebijakan.kemkes.go.id/hasil-ski-2023/.

[4] Konstantinos Papatheodorou et al., "Complications of Diabetes 2017," *Journal of Diabetes Research* 2018 (2018): 4, https://doi.org/https://doi.org/10.1155/2018/3086167.

triglycerides to high-density lipoprotein cholesterol (HDL-C). AIP is a better indicator of atherosclerosis risk than low-density lipoprotein cholesterol (LDL-C) and can be used as a risk factor assessment[5].

One major contributor to dyslipidemia in T2DM patients is the high consumption of saturated fats. Foods rich in polyunsaturated fatty acids (PUFA) and fiber, such as vegetables, legumes, nuts, cereals, seeds, and fruits, can lower lipid profiles in T2DM patients[6]. One such legume high in fiber and phytochemicals, including polyphenols with potent antioxidant properties, is the bambara groundnut (*Vigna subterranea*)[7]. In Addition to legumes, tubers also contain complex carbohydrates, amino acids, sterols, and fatty acids, which are often underutilized. One such tuber is the suweg tuber (*Amorphophallus paeoniifolius*) [8].

Suweg tuber has excellent potential as a functional food for T2DM management. The fiber content in fresh suweg tubers per 100 grams is 1.4 grams. Suweg tubers contain two key bioactive compounds: dietary fiber and water-soluble polysaccharides, which can reduce blood glucose levels[9]. The starch content in suweg tubers per 100 grams is 83.86%[10]. Additionally, Suweg tubers contain approximately 30% glucomannan, which acts similarly to water-soluble fiber. Glucomannan helps lower blood glucose levels by forming a

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[5] Julie J. Kim et al., "Predictive Value of the Atherogenic Index of Plasma (Aip) for the Risk of Incident Ischemic Heart Disease among Non-Diabetic Koreans," *Nutrients* 13, no. 9 (2021), https://doi.org/10.3390/nu13093231.

[6] Gustina Berta Uli, Sekar Ramadhanti Asyahir, and Leny Budhi Harti, "Studi Literatur: Pengaruh Diet Mediterania Terhadap Profil Lipid Dan Glukosa Darah Puasa Pada Orang Overweight Atau Obesitas," *Amerta Nutrition* 7, no. 1 (2023): 139–46, https://doi.org/10.20473/amnt.v7i1.2023.139-146.

[7] O. T. Olanipekun et al., "Effect of Bambara Groundnut (Vigna Subterranea) Consumption on Biomarkers of Oxidative Stress in Alloxan-Induced Diabetic Wistar Rats," *Research Journal of Food Science and Nutrition* 4, no. 3 (2019): 65–72, https://doi.org/10.31248/rjfsn2019.066.

[8] Henny Ayu Pramesti, Kusoro Siadi, and Edy Cahyono, "Analisis Rasio Kadar Amilosa/Amilopektin Dalam Amilum Dari Beberapa Jenis Umbi," *Indonesian Journal of Chemical Science* 4, no. 1 (2015): 26–30, http://journal.unnes.ac.id/sju/index.php/ijcs.

[9] Lianah et al., "Aplikasi Umbi Suweg (*Amorphophallus Campanulatus*) Sebagai Alternatif Penurun Gula Darah Pada Penderita Diabetes Mellitus," *Al-Hayat: Journal of Biology and Applied Biology* 1, no. 1 (2018): 1, https://doi.org/10.21580/ah.v1i1.2666.

[10] Pramesti, Siadi, and Cahyono, "Analisis Rasio Kadar Amilosa/Amilopektin Dalam Amilum Dari Beberapa Jenis Umbi."

thick gel that moves through the small intestine and is then fermented by microflora in the large intestine[11].

Previous studies have shown that the consumption of bambara groundnuts, which are rich in fiber and nutrients, can improve T2DM and its related complications[12]. The fiber content in dried bambara groundnut per 100 grams is 26.3 grams[13]. The high fiber and phytochemical content of bambara groundnut can significantly lower fasting blood glucose levels in diabetic rats fed several formulations of bambara groundnut-based diets, indicating their vital role in combating T2DM[14].

Several plant-based foods, such as legumes and tubers with high fiber content, have been proven effective in preventing several diseases. Allah SWT has mentioned in the Qur'an (Surah 'Abasa 80: 24-32) a variety of fiber-rich foods, including vegetables and fruits, as part of the sustenance provided by the heavens. This verse highlights the importance of plant-based foods, including grasses containing cellulose, which are indigestible by the human body but provide essential health benefits[15].

1.2 Research Problems

Is there an effect of suweg tuber flour (*Amorphophallus paeoniifolius*) and bambara groundnut flour (*Vigna subterranean*) formulation on blood glucose levels and the atherogenic index in diabetic dyslipidemia rats?

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[11] Y. Maphosa, V. A. Jideani, and L. Maphosa, "Bambara Groundnut Production, Grain Composition and Nutritional Value: Opportunities for Improvements," *Journal of Agricultural Science* 160, no. 6 (2022): 448–58, https://doi.org/10.1017/S0021859622000521.

[12] Mhya Daniel Hassan and Mohammed Abdulrashid, "Effects of Consuming Different Varieties of Bambara Nut (Vigna Subterranea) Seeds on Liver and Kidney of Diabetic and Non-Diabetic Subject," *Journal of Drug Delivery and Therapeutics Open* 11, no. 5-S (2021): 6–12, https://doi.org/http://dx.doi.org/10.22270/jddt.v11i5-S.5011.

[13] Kementerian Kesehatan Republik Indonesia, *Tabel Komposisi Pangan Indonesia*, ed. Doddy Izwardy (Jakarta: Kementerian Kesehatan Republik Indonesia, 2018).

[14] Hassan and Abdulrashid, "Effects of Consuming Different Varieties of Bambara Nut (Vigna Subterranea) Seeds on Liver and Kidney of Diabetic and Non-Diabetic Subject."

[15] Lajnah Pentashihan Mushaf Al-Qur'an, Badan Litbang & Diklat Kementerian Agama RI, and Lembaga Ilmu Pengetahuan Indonesia (LIPI), *Makanan Dan Minuman Dalam Perspektif Al-Qur'an Dan Sains*, *Lajnah Pentashihan Mushaf Al-Qur'an*, 1st ed., vol. 37 (Jakarta: Lajnah Pentashihan Mushaf Al-Qur'an, 2013), https://doi.org/10.1111/j.2042-7158.1985.tb05098.x.

1.3 Research Objectives

1. General Purpose

   The general purpose of this study is to analyze the effect of suweg tuber flour (*Amorphophallus paeoniifolius*) and bambara groundnut flour (*Vigna subterranean*) formulation on blood glucose levels and the atherogenic index in diabetic dyslipidemia.

2. Specific Purposes

   a. To analyze the effect of suweg tuber flour (*Amorphophallus paeoniifolius*) and bambara groundnut flour (*Vigna subterranean*) formulation on blood glucose levels in diabetic dyslipidemia rats.

   b. To analyze the effect of suweg tuber flour (*Amorphophallus paeoniifolius*) and bambara groundnut flour (*Vigna subterranean*) formulation on the atherogenic index in diabetic dyslipidemia rats.

1.4 Research Benefits

1. Theoretical Benefits

   The results of this study are expected to contribute to the development of scientific knowledge in the field of nutrition, particularly about functional foods such as bambara groundnut and suweg tubers, as an effort to reduce blood glucose levels and the atherogenic index in diabetic patients. Additionally, this study aims to strengthen previous research and serve as valuable data for future studies.

2. Practical Benefits

   The expected practical benefits are as follows:

   1. For the Writer

      As a platform for applying the knowledge acquired during the learning process.

   2. For the Community

      As a source of information regarding the potential of bambara groundnut and suweg tubers as an alternative approach to lowering blood glucose levels and the atherogenic index.

3. For Educational Institutions

   To provide applicable, scientific, and beneficial contributions to the field of nutrition science while enriching the knowledge of bambara groundnut and suweg tubers as functional food sources.

1.5 Authenticity Research

Table 1. Authenticity Research

Research Title	Types of Research	Variable	Result	Research Differences
Effect of Consuming Different Varieties of Bambara Groundnut (*Vigna Subterranea*) Seeds on Glycaemia and Lipid Profile of Diabetic and Non-Diabetic Rats[16]	Experimental post-test only control group	Dependent: Glycaemia and Lipid Profile Independent: Different Varieties of Bambara Groundnut (*Vigna Subterranea*) Seeds	There was a continuous increase in glycemic levels in diabetic rats fed a basal and normal diet compared to those fed the formulated diet. The glycemic levels of non-diabetic rats fed the formulated and normal/basal diets remained within the normal range. The lipid profile of diabetic rats fed a basal/normal diet increased and significantly differed from those fed the formulated diet ($p < 0.05$, p-value = 0.17).	Independent: Bambara Groundnut flour and suweg tuber flour formulation Dependent: atherogenic index Type of research: Pre-posttest with random control group design
Effect of Bambara groundnut (*Vigna subterranea*) consumption on biomarkers of oxidative stress in	Experimental post-test only control group	Dependent: biomarkers of oxidative stress Independent:	Group C rats had the lowest post-meal glucose concentration (75 mg/dl).	Independent: formulation of bambara groundnut flour and

[16] Hassan and Abdulrashid, "Effects of Consuming Different Varieties of Bambara Nut (Vigna Subterranea) Seeds on Liver and Kidney of Diabetic and Non-Diabetic Subject." *Journal of Drug Delivery and Therapeutics Open* 11, no. 5-S (2021): 6-12, http://dx.doi.org/10.22270/jddt.v11i5-S.5011

Research Title	Types of Research	Variable	Result	Research Differences
alloxan-induced diabetic Wistar Rats[17]		bambara groundnut (*Vigna Subterranea*)	AST, ALT, and ALP decreased in rats fed a bambara groundnut diet. ($p<0.05$) with p-values of 0.45; 0.60; 0.90, respectively. Conclusion: bambara groundnut can modulate and improve oxidative stress in diabetic rats.	suweg tuber flour Dependent: blood glucose levels and atherogenic index Type of Research: Pre-posttest with control group design
Suweg Flour (*Amorphophallus campanulatus*) Potential Reducing TNF-α Levels in Model Diabetic Rats[18]	Experimental design with a pre-posttest control group.	Dependent: TNF-a Levels Independent: Suweg flour	There was a significant difference before and after treatment ($p < 0.001$); a significant difference was observed among all groups ($p < 0.001$); P suweg Flour 2.50 - 1.25 < 0.001; P suweg Flour 2.50 – Standard = 0.002. It can be concluded that suweg flour can reduce TNF-α in diabetic rats; however, its effect is still lower than the standard treatment.	Independent: formulation of bambara groundnut flour and suweg tuber flour Dependent: blood glucose levels and atherogenic index

[17] Olanipekun et al., "Effect of Bambara Groundnut (Vigna Subterranea) Consumption on Biomarkers of Oxidative Stress in Alloxan-Induced Diabetic Wistar Rats." *Research Journal of Food Science and Nutrition* 4, no. 3 (2019): 65-72, https://doi.org/10.31248/rjfsn2019.066

[18] Ika Setyawati, "Suweg Flour (Amorphophallus Campanulatus) Potential Reducing TNF-α Levels in Model Diabetic Rats," *Mutiara Medika: Jurnal Kedokteran Dan Kesehatan* 20, no. 2 (2020): 3–7, https://doi.org/10.18196/mm.200246. *Mutiara Medika: Jurnal Kedokteran dan Kesehatan* 20, no. 2 (2020): 3-7, https://doi.org/10.18196/mm.200246

Research Title	Types of Research	Variable	Result	Research Differences
Nutritional Composition and Antidiabetic Effect of Germinated Endosperm (*Borassus flabellifer*), tuber (*Amorphophallus Paeoniifolius*) and Their Combinated Impact on Rats[19]	Experimental design with a pre-posttest control group	Dependent: Fasting blood glucose levels Independent: the combination of lontar fruit seed sprouts and suweg tubers	The combination of lontar seed sprouts and suweg tubers significantly reduced blood glucose levels ($p < 0.001$) in alloxan-induced diabetic rats by the sixth week of treatment, reaching 7.71 mmol/L (<10 mmol/L). Conclusion: Combining these two food ingredients can restore the function of damaged pancreatic β-cells by the end of the sixth week.	Independent: formulation of bambara groundnut flour and suweg tuber flour Dependent: atherogenic index
Proximate Composition, Phytochemical Screening and Anti-Hyperglycemic Effect of Elephant Foot Yam (*Amorphophallus Paeoniifolius)* Tuber on Alloxan Induced Diabetic Rats[20]	Experimental design with a pre-posttest control group	Dependent: Proximate compositin, phytochemical screening and anti-hyperglycemic Independet: Elephant foot yam (*Amorphophallus paeoniifolius*) tuber	Fasting blood glucose (FBG) levels decreased significantly ($p < 0.05$, p-value = 0.75) in diabetic rats after the first week, and the reduction became highly significant ($p \leq 0.001$, p-value = 0.53) after the third week of feeding and continued until	Independent: formulation of bambara groundnut flour and suweg tuber flour Dependent: atherogenic index

[19] Shaikh Shahinur Rahman et al., "Nutritional Composition and Antidiabetic Effect of Germinated Endosperm (*Borassus Flabellifer*), Tuber (*Amorphophallus Paeoniifolius*) and Their Combined Impact on Rats," *Biochemistry and Biophysics Reports* 25, no. 100917 (2021): 1–6, https://doi.org/10.1016/j.bbrep.2021.100917.

[20] Shaikh Shahinur Rahman et al., "Proximate Composition, Phytochemical Screening and Anti-Hyperglycemic Effect of Elephant Foot Yam (*Amorphophallus Paeoniifolius*) Tuber on Alloxan Induced Diabetic Rats," *Progress in Nutrition* 23, no. 2 (2021): 1–9, https://doi.org/10.23751/pn.v23i2.9611.

Research Title	Types of Research	Variable	Result	Research Differences
			the sixth week. Conclusion: Suweg tubers can be a functional food for treating diabetes mellitus.	
Pengaruh Pemberian Ekstrak Bekatul Beras Hitam (*Oryza sativa L. indica*) terhadap Kadar MDA, SOD dan Trigliserida pada Tikus Diabetes Mellitus Tipe 2[21]	Quasi-experimental with pre-and-post testing randomixed control group design	Dependent: MDA, SOD and triglyceride levels Independent: Black rice bran extract (*Oryza sativa L. indica*)	A black rice bran extract dose of 60/200 g BW reduced MDA levels in rats from 9.82 mmol/mL to 2.21 mmol/mL, increasing SOD levels from 23.49 units/mL to 69.67 units/mL (p = 1000). It lowered triglyceride levels from 147.16 mg/dL to 85.17 mg/dL, nearly matching the effects of 9 mg/200 g metformin intervention (p > 0.05). Conclusion: There was a reduction in MDA and triglyceride levels and an increase in SOD levels in rats given black rice bran extract intervention.	Independent: formulation of bambara groundnut flour and suweg tuber flour Dependent: blood glucose levels and atherogenic index Type of research: True-experimental Pre-posttest with control group design
Efek Kombinasi Bubuk Mengkudu dan Kelor terhadap Glukosa Darah	True experimental with pretest-posttest and control group design	Dependent: fasting blood glucose levels	Group P2 experienced the highest reduction in fasting blood	Independent: formulation of bambara groundnut flour and

[21] Monikasari et al., "Pengaruh Pemberian Ekstrak Bekatul Beras Hitam (Oryza Sativa L. Indica) Terhadap Kadar MDA, SOD Dan Trigliserida Pada Tikus Diabetes Mellitus Tipe 2," *AcTion: Aceh Nutrition Journal* 8, no. 1 (2023): 129, https://doi.org/10.30867/action.v8i1.731.

Research Title	Types of Research	Variable	Result	Research Differences
Puasa Tikus DMT2 Dislipidemia[22]		Independent: the combination of mengkudu powder and moringa	glucose (FBG) levels, from 176.20 ± 20.25 mg/dL (p = 0.043). Conclusion: The combined moringa leaves and noni powder can significantly reduce fasting blood glucose levels.	suweg tuber flour Dependent: blood glucose levels and atherogenic index

[22] Alfian Abdul Rajab, Adi Magna Patriadi Nuhriawangsa, and Setyo Sri Rahardjo, "Efek Kombinasi Bubuk Mengkudu Dan Kelor Terhadap Glukosa Darah Puasa Tikus Dmt2 Dislipidemia," *Gizi Indonesia* 46, no. 1 (2023): 57–66, https://doi.org/10.36457/gizindo.v46i1.765.