



## Potential of Dioscorea Hispida dennst to Deflate Blood Glucose Level

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### ABSTRACT

Treatment of DM sufferers impacts the economic side related to the cost of drugs or pharmacological therapy, which is quite expensive. Gadung tubers (*Dioscorea Hispida dennst.*) can be an option for people with diabetes because, in addition to containing low carbohydrates, they also contain several bioactive compounds that can be beneficial for the body. This study aims to analyze the effect of the consumption of Gadung tubers (*Dioscorea hispida dennst*) on the blood glucose levels of people with diabetes mellitus in Kolaka. This type of research is a quasi-experimental design using a one-group pre-post test design involving 30 men and women with DM who were recorded as active in Posbindu visits in Toari District taken purposively. The intervention was carried out for ten days for August – September 2021 by measuring the blood glucose levels of respondents before and after consuming processed Gadung tubers. The research data were analyzed using paired t-test. The results showed differences in the respondents' glucose levels before and after the intervention, where statistically, a p-value of  $0.0001 < 0.05$  was obtained, which means that there was a significant effect of the consumption of Gadung tubers on the glucose levels of DM patients. This study concluded that processed yam could be an alternative food for people with diabetes.

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### ABSTRAK

Perawatan penderita DM memberikan dampak pada sisi ekonomi dimana hal tersebut berkaitan dengan biaya obat atau terapi farmakologis tergolong mahal. Umbi gadung (*Dioscorea Hispida*) dapat menjadi pilihan bagi penderita DM karena selain mengandung karbohidrat rendah juga mengandung beberapa senyawa bioaktif yang dapat bermanfaat bagi tubuh. Studi ini bertujuan untuk menganalisis pengaruh konsumsi olahan ubi gadung (*dioscorea hispida dennst*) terhadap kadar glukosa darah penderita diabetes mellitus di Kolaka. Jenis penelitian ini adalah quasi eksperimental menggunakan desain one group pre post test design yang melibatkan 30 orang laki-laki dan perempuan penderita DM yang tercatat aktif dalam kunjungan Posbindu di Kecamatan Toari diambil secara purposive. Intervensi dilakukan selama sepuluh hari periode Agustus – September 2021 dengan pengukuran kadar glukosa darah responden sebelum dan setelah mengkonsumsi olahan umbi Gadung. Data penelitian dianalisis menggunakan uji t test berpasangan. Hasil penelitian menunjukkan bahwa terdapat perbedaan kadar glukosa responden sebelum dan setelah dilakukan intervensi, dimana secara statistic didapatkan p-value  $0.0001 < 0.05$  yang berarti ada pengaruh yang signifikan dari konsumsi umbi Gadung terhadap kadar glukosa penderita DM. penelitian ini menyimpulkan bahwa olahan ubi gadung dapat menjadi makanan alternative bagi penderita DM.

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## INTRODUCTION

Diabetes is a serious chronic disease that occurs when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Diabetes is an important public health problem, becoming one of the four priority non-communicable diseases targeted for follow-up by world leaders. The number of cases and prevalence of diabetes has continued to increase over the last few decades (KEMENKES RI, 2019).

Based on global data in 2017, there were 451 million (aged 18–99 years) with diabetes worldwide. These figures are likely to increase to 693 million by 2045. It is estimated that nearly half of the entire world population (49.7%) living with diabetes is undiagnosed. In addition, it is estimated that there are 374 million people with impaired glucose tolerance (IGT), and it is projected that nearly 21.3 million live births of women are affected by hyperglycemia in pregnancy. In 2017, about 5 million deaths worldwide were caused by diabetes in 20–99 years. Global healthcare costs for people with diabetes are estimated to reach USD 850 billion in 2017 (Cho NH, 2018).

Basic Health Research (Riskesmas) shows a significant increase in the prevalence of diabetes since 2013, with a percentage of 6.9% to 8.5% in 2018. It continues with the estimated number of sufferers in Indonesia reaching more than 16 million sufferers. These patients are at high risk of developing other diseases, such as heart attacks, strokes, blindness, kidney failure, and even paralysis and death (KEMENKES RI, 2018). Specifically, in Kolaka Regency, the number of people with Diabetes Mellitus was 18,055 in 2019, and only 2,675 of them had received basic care (Dinkes Kolaka, 2019).

DM treatment impacts the economy, related to the cost of treatment or pharmacological therapy, which is quite expensive. For this reason, the central government, through the Indonesian Ministry of Health, encourages the development of alternative herbal or traditional treatments to reduce the burden of health care budgets and the efficacy and lack of side effects that can arise from herbal medicines (Rokom, 2019).

Gadung tubers (*Dioscorea hispida* dennst) can be a choice of consumption material for people with diabetes because apart from containing low carbohydrates, they also contain several bioactive compounds such as Water-Soluble Polysaccharides (PLA), Diosgenin and Dioscorine (Sumunar & Estiasih, 2015). Diosgenin is effective against diabetes and its complications through several mechanisms, including reducing glucose absorption in the intestine, affecting glucose metabolism in tissues and organs, improving insulin resistance, increasing insulin secretion (Gan, et al., 2020).

The results of previous studies showed an effect of infusion of Gadung tuber (*Dioscorea hispida* Dennst) on the reduction of blood sugar levels in diabetic rats induced by Alloxan. Gadung tuber trials on Wistar rats with diabetes at doses of 630 mg/KgBW and 1360 mg/kgBW showed decreased blood glucose levels. The decrease in blood glucose levels in Gadung tuber infusion with levels of 1260 mg/kg BW was comparable to the effect of insulin administration on positive controls ( $p < 0.05$ ) (Sunarsih, 2007).

Based on these scientific facts and to the best of our knowledge, there have been no studies that have tried to explore the effect of yam on the reduction of human blood glucose levels. Therefore, this study aims to analyze the effect of the consumption of Gadung tuber (*Dioscorea*

*hispida* dennst) on blood glucose levels in people with diabetes mellitus in Kolaka.

## METHOD

### *Participant characteristics and research design*

This type of research is quasi-experimental with a one-group pre-post test design approach that aims to determine the effect of Gadung tubers' consumption on DM patients' blood glucose levels in Toari District, Kolaka Regency.

The research population was 114 people with diabetes mellitus, while the research sample was set at 30 respondents. The sampling technique used is purposive sampling. The sample included in this study came from Toari district, the province of Southeast Sulawesi (Kolaka Regency) and actively participated in the Integrated Guidance Post (Posbindu) activities recorded in the last two years (2019 – 2021). Overall, 30 men and women with Diabetes Mellitus were selected as samples in this study. Exclusion criteria were the presence of complications with other diseases such as gastritis and gangrene.

### *Sampling procedures*

All DM patients in Kec. Toari was met during the Posbindu activity, which is held every month on the 5th. We conveyed information regarding the planned research activity to participants on the sidelines of the queue for routine checks (blood pressure, blood sugar, cholesterol, and uric acid). All participants who attended the Posbindu activity amounted to 89 people. After being screened, we excluded 42 people due to the unsuitable criteria; 17 Posbindu participants were unwilling to participate. Finally, the total number of patients willing to participate in this study was 30 and stated their willingness in the informed consent form.

This study received ethical approval issued by the Health Research Commission of the Faculty of Medicine, Halu Oleo University, No. 128 / UN29.17.1.3/ETIK/2021.

### *Sample size, power, and precision*

We prepared materials and equipments such as blood glucose measuring devices (*One Touch*), glucose strips, observation sheets, and digital analytical balances. The main preparation is Gadung tubers, where the processing is carried out carefully because it must be ensured that when given to the respondent, it does not contain toxic cyanide acid (HCN) or is at a safe level according to FAO guidelines, which is below 10 ppm. We implemented the detoxification method of Gadung tubers using salt and kitchen ash according to previous research. Measurement of HCN levels after Gadung tubers were detoxified was carried out in the integrated laboratory of the Faculty of Medicine, Halu Oleo University, using a Spectrophotometer. Furthermore, Gadung tubers flour is packed in plastic wrap, where the net weight in one plastic package is 1000 grams intended to be consumed by respondents in one day (3 meals). Of the 30 respondents, each received 10 packs to be consumed for 10 days, so that the total packages given to all respondents were 300 packs with a total weight of 300 kg.

The intervention for the consumption of Gadung Tuber (*Dioscorea hispida* dennst) began on August 28, 2021. First,

together with Posbindu cadres conducted door-to-door visits to respondents who had been assigned to submit Gadung tuber flour. We provide flexibility to respondents and their families regarding the choice of food supply model for respondents, as long as they do not use other ingredients that can interfere with or contradict the effectiveness of the yam tuber.

We visited each respondent's house every morning and evening to control the respondent's condition and ensure that the respondent spent the dose of Gadung tuber material that had determined, including directing what respondents consumed.

The intervention ended on September 7, 2021, and then the research team evaluated the intervention by measuring the respondents' blood glucose levels. Blood sugar measurements to evaluate the effectiveness of Gadung sweet potato were carried out in the morning before the respondent had breakfast.

#### Data analysis

The data is processed by SPSS v. program. 20.0, the presentation of data in the form of tables and narratives based on the variables studied. Data were analyzed descriptively (univariate) and bivariate using paired t-test. The test results were considered significant if the p-value was <0.05.

## RESULT AND DISCUSSION

At the end of this study, all respondents successfully participated until the end of the intervention. Furthermore, there were no respondents who resigned or experienced health problems due to consuming Gadung tubers.

#### Respondents Characteristics

Descriptive analysis of the demographic characteristics of the respondents is shown in Table 1

**Table 1.**  
*Frequency Distribution of Respondents Characteristics*

Characteristics	Frequency	
	n	%
Age (years)		
46 – 55	8	26.7
56 – 65	18	60
> 65	4	13.3
Employment		
Farmer	4	13.3
Housewife	19	63.3
Entrepreneur	7	23.3

Table 1 shows that most of the respondents are included in the elderly category, namely aged 56 – 65 years (60%), do not work or as housewives, as many as 19 respondents (63.3). In addition, based on age and employment, most respondents are prone to chronic diseases, one of which is Diabetes Mellitus.

#### Blood glucose levels pre – post intervention

All respondents managed to pass the 10-day intervention period with great enthusiasm. Qualitatively, none of the

respondents reported any side effects while consuming Gadung tuber in the intervention period of this study. Furthermore, based on the observation of blood glucose levels before and after the intervention showed positive progress. A comparison of the blood glucose levels before and after the intervention can be seen in table 2.

**Table 2.**  
*Blood Glucose Levels of Respondents Pre and Post Intervention*

Intervention	n	Mean	Std. Deviasi
Pre-test	30	329.20	78.479
Post-test	30	199.93	32.282

The average value (mean) of blood sugar before the intervention was 329.20 with a standard deviation of 78.479, and then after the respondent consumed Gadung Tuber after ten days with a frequency of 3 times a day, there was a decrease in blood sugar levels with the average value (mean) being 199.93 with a standard deviation of 32,282. Therefore, it shows that there is a decrease in blood sugar levels of 217.27 mg/dl.

**Table 3.**  
*The results of the analysis of the consumption of Gadung tubers on the respondents' blood glucose levels*

Gadung Intervention	N	Mean ± SD	p-value
Pre-test	30	329.20±78.479	0.0001
Post-test	30	199.93±32.282	

The results of the independent t-test showed that the p-value was 0.0001 <0.05. it means that giving Gadung tuber for ten days with a frequency of 3 times per day effectively lowers blood sugar levels.

Research on traditional medicine systems has become a promising approach to find therapeutic agents. This requires extracts containing many compounds and extracts with moderately active metabolites that can provide strong synergistic pharmacological effects (Fabricant & Farnsworth, 2001; Leonti & Casu, 2013; Miah, Das, Ibrahim, Shajib, & Rashid, 2018).

In general, the results of the Gadung tuber intervention in this study showed a significant reduction in glucose levels in DM patients; this was evidenced by statistical analysis of p-value 0.0001 <0.05. In addition, the respondent's compliance during the ten days is very supportive of the success of the intervention stage. In collaboration with Posbindu cadres and the respondent's family, the research team carried out close supervision during the intervention process regarding the food and beverages consumed by the respondents.

Based on the results of interviews with the community around the Toari Sub-district, it was found that Gadung tubers (*Dioscorea Hispida dennst*) grew a lot around their residence. Gadung tuber is a wild plant that local people usually use as snacks or processed in the form of crackers. Toari people do not know the health benefits that can be obtained from Gadung, and people only know that these tubers contain a toxic substance known as cyanide acid (HCN). The average content of HCN in Gadung tubers is 362 ppm (Sasongko, 2009). According to FAO, the safe limit for consumption of cyanide is ten ppm. The high cyanide acid in

Gadung tubers is a limiting factor for the feasibility of Gadung for consumption. Therefore, adequate processing is needed to reduce or eliminate cyanide in Gadung before consumption (Pramitha & Wulan, 2017).

Gadung tubers are a good source of carbohydrates because they have a low glycemic index. Boiled Gadung tubers measuring 85 grams have a low glycemic index of 51. In boiled, peeled taro tubers measuring 57 grams glycemic index 54, boiled potatoes measuring 85 grams glycemic index 54, white rice 170 grams glycemic index 72, and ripe bananas glycemic index 82 (Maulida & Estiasih, 2014).

Based on the content test, Gadung tubers (*Dioscorea Hispida* dennst) contains several bioactive compounds such as Water-Soluble Polysaccharides (PLA), Diosgenin and Dioscorine (Sumunar S. , 2014). PLA has antioxidant activity (Anwar, Birch, Ding, & Bekhit, 2020) (Xue, et al., 2020), inhibits activity of angiotensin-converting enzyme (ACE) (Zhang, et al., 2019), antimicroba (Wilson, et al., 2017), and hipoglycemia (Li, Gao, & Zou, 2017) (Choudhury, et al., 2017) (Huang, Xie, Yu, & Shen, 2020), and as imunomodulator (Makiyah & Djati, 2018). Dioscorine content in Gadung flour is 8.17% (Hartati, Yulianto, & Handayani, 2010). Dioscorin has functional properties such as antioxidant activity, oxygen scavenger (binding oxygen so it does not support oxidation reactions), and an enzyme inhibitor (Arunachalam & Narmadhapriya, 2011), meningkatkan metabolisme pada tikus obesitas dan menurunkan tekanan darah sistolik (Shih, Lin Y-S, & Hou, 2015). The diosgenin content of Gadung tubers is 2.33 mg/100g of material in the tubers, and when processed into flour, the levels increase to 28.20 mg/100g of ingredients (Sumunar S. , 2014). Diosgenin is effective against diabetes and its complications through several mechanisms, including decreasing glucose absorption in the intestine, influencing glucose metabolism in tissues and organs, improving insulin resistance, increasing insulin secretion (Londzin, et al., 2020). In the medical field, diosgenin is widely used to reduce blood glucose levels (Saputro & Estiasih, 2015).

Research by Qingxia Gan et al. (Gan, et al., 2020) stated that Diosgenin could inhibit glucose absorption in the intestine, increase the absorption and utilization of glucose by tissues and organs, inhibit hepatic glycogen decomposition, regulate hormone secretion, inhibit insulin resistance, increase insulin secretion, and improve diabetes. Moreover, it is well known that most of the complications of diabetes are not only related to abnormal glucose and lipid metabolism but are also closely related to inflammation and oxidative stress. Therefore, Diosgenin also has good anti-inflammatory and anti-oxidative effects, showing an excellent therapeutic effect on diabetes complications. For example, Diosgenin can inhibit PNF-B, increase antioxidant enzymes such as IKK $\beta$  and NF-B phosphorylation, decrease ROS levels, and reduce the expression of Bax protein and caspase-3, thereby reducing diabetes complications.

Further research by Deni Maulida (Maulida & Estiasih, 2014) stated that water-soluble polysaccharides (PLA) could inhibit food digestion and inhibit carbohydrate absorption, thereby inhibiting postprandial increases in blood glucose and insulin concentrations. Furthermore, other compounds such as Astragalus Polysaccharides (APS) exert their hypoglycemic activity by decreasing hepatic insulin resistance response and reducing stress on the endoplasmic reticulum. In addition, treatment of obese and diabetic rats with APS resulted in a significant reduction of hyperglycemia, restoration of insulin sensitivity, resolution of fatty liver disease, improvement of insulin action in liver tissue.

## LIMITATION OF THE STUDY

The number of samples in this study may be considered insufficient. Still, we believe this to represent a reasonably accurate result considering that we have controlled for factors that may influence the results of this study, such as drug consumption, consumption patterns, and timing of blood glucose measurements of the sample.

## CONCLUSION AND RECOMMENDATIONS

Processed Gadung tubers have been shown to reduce blood sugar levels in DM patients after ten days of administration. Gadung tubers containing diosgenin, Water Soluble Polysaccharides (PLA) and Astragalus Polysaccharides (APS) could lower blood glucose levels.

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## ETHICAL CONSIDERATIONS

This research has received ethical approval issued by the Health Research Commission of the Faculty of Medicine, Halu Oleo University, No. 128 / UN29.17.1.3/ETIK/2021.

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## Conflict of Interest statement

The author declares that there is no conflict of interest.

## REFERENCES

- Anwar, M., Birch, E., Ding, Y., & Bekhit, A. (2020). Water-soluble non-starch polysaccharides of root and tuber crops: extraction, characteristics, properties, bioactivities, and applications. *Critical reviews in food science and nutrition* , 33.
- Arunachalam, C., & Narmadhapriya, D. (2011). Monascus fermented rice and its beneficial aspects: a new review. *Asian Journal of Pharmacology Clinical Research* , 4, 29-31.
- Cho NH, S. J. (2018). IDF Diabetes Atlas: Global Estimates of Diabetes Prevalence for 2017 and Projections for 2045. *Diabetes Research and Clinical Practice* , 271-81.
- Choudhury, H., Pandey, M., Hua, C. K., Mun, C. S., Jing, J. K., Kong, L., et al. (2017). An update on natural compounds in the remedy of Diabetes Mellitus: A systematic Review. *Journal of traditional and complementary medicine* , 8 (3), 361-376. <https://doi.org/10.1016/j.itcme.2017.08.012>



- Dinkes Kolaka. (2019). *Profil Kesehatan Kab. Kolaka 2019*. Kolaka: Dinas Kesehatan Kab. Kolaka.
- Fabricant, D., & Farnsworth, N. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspective*, 69-75.
- Gan, Q., Wang, J., J. H., G. L., H. X., C. P., et al. (2020). The role of Diosgenin in Diabetes and Diabetic complications. *Journal of Steroid Biochemistry and Molecular Biology*, 198.
- Hartati, I., Yulianto, M., & Handayani, D. (2010). REDUKSI DIOSCORIN DARI UMBI GADUNG MELALUI EKSTRAKSI GELOMBANG MIKRO. *Prosiding seminar nasional dan internasional*.
- Huang, R., Xie, J., Yu, Y., & Shen, M. (2020). Recent progress in the research of yam mucilage polysaccharides: isolation, structure and bioactivities. *International journal of Biological macromolecules*(155), 1262-1269.
- KEMENKES RI. (2019). *Hari Diabetes Sedunia Tahun 2018*. Jakarta: Kementerian Kesehatan RI.
- KEMENKES RI. (2018). *Hasil Utama Riset Kesehatan Dasar (RISKESDAS)*. Jakarta: Kementerian Kesehatan RI.
- Leonti, M., & Casu, L. (2013). Traditional medicines and Globalization: current and future perspectives in ethnopharmacology. *Frontier Pharmacology*, 92.
- Li, Q., Gao, W., & Zou, Y. (2017). Hypoglycemic effect of Chinese yam (*Dioscorea opposita rhizoma*) polysaccharide in different structure and molecular weight. *Journal of Food Science*, 82(10), 2487-2494.
- Londzin, P., Kisiel-Nawrot, E., Kocik, S., Janas, A., Trawczyński, M., Cegiela, U., et al. (2020). Effects of diosgenin on the skeletal system in rats with experimental type 1 diabetes. *Biomedicine & Pharmacotherapy*(129), 110342.
- Makiyah, S. N., & Djati, M. S. (2018). Potency of purple yam (*Dioscorea alata* L.) as an immunomodulatory agent. *Berkala Kedokteran*, 14(1), 89-98.
- Maulida, D., & Estiasih, T. (2014). Efek Hipoglikemik Polisakarida Larut Air Umbi Gadung (*Dioscorea Hispida*) Dan Alginat: Kajian Pustaka. *Jurnal Pangan dan Agroindustri*, 2(3), 136-40.
- Miah, M., Das, P., Ibrahim, Y., Shajib, M., & Rashid, M. (2018). In Vitro antioxidant, antimicrobial, membrane stabilization and thrombolytic activities of *Dioscorea Hispida* Dennst. *European Journal of Integrative Medicine*, 19, 121-127.
- Pramitha, A., & Wulan, S. (2017). Detoksifikasi sianida umbi gadung (*Dioscorea hispida* Dennst.) dengan kombinasi perendaman dalam abu sekam dan perebusan. *Jurnal Pangan dan Agroindustri*, 5(2).
- Rokom. (2019, Agustus 21). *Pemerintah dorong pengembangan industri obat tradisional*. Retrieved January 05, 2021, from Sehat Negeriku: <https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20190820/5431405/kemenkes-dorong-pengembangan-industri-obat-tradisional/>
- Saputro, A., & Estiasih, T. (2015). Pengaruh polisakarida larut air (PLA) dan serat pangan umbi-umbian terhadap glukosa darah: kajian pustaka. *Jurnal pangan dan agroindustri*, 3(2), 756-62.
- Sasongko, P. (2009). Detoksifikasi umbi gadung (*Dioscorea hispida* Dennst.) melalui proses fermentasi menggunakan kapang *Mucor* sp. *Jurnal Teknologi Pertanian*, 10(3), 205-15.
- Shih, S.-L., Lin Y-S, L. S.-Y., & Hou, W.-C. (2015). Effects of yam dioscorin interventions on improvements of the metabolic syndrome. *Botany Studies*, 56(4).
- Sumunar, R., & Estiasih, T. (2015). Umbi Gadung (*Dioscorea Hispida* dennst) sebagai bahan pangan mengandung senyawa bioaktif. *Jurnal Pangan dan Agroindustri*, 108-12.
- Sumunar, S. (2014). Karakteristik Fisiko Kimia, Bioaktif Dan Organoleptik Mie Berbasis Tepung Gadung (*Dioscorea Hispida* Dennst).
- Sunarsih, E. (2007). Pengaruh pemberian infusa umbi Gadung (*Dioscorea Hispida* dennst) terhadap penurunan kadar glukosa darah tikus putih jantan diabetes yang diinduksi aloksan. *Majalah Farmasi Indonesia*, 29-33.
- Wilson, D., Nash, P., Buttar, H., Griffiths, K., Singh, R., Meester, D., et al. (2017). The role of food antioxidants, benefits of functional foods, and influence of feeding habits on the health of the older person: An overview. *Antioxidants*, 6(4), 81.
- Xue, H. Y., Zhao, Y., Liu, Z. H., Wang, X. W., Zhang, J. W., Peng, X., et al. (2020). Recovery of yam soluble protein from yam starch processing wastewater. *scientific reports*, 10(1), 1-12.
- Zhang, L., Ng, T. B., Lam, J. K., Wang, S. W., Lao, L., Zhang, K. Y., et al. (2019). Research and development of proteins and peptides with therapeutic potential from yam tubers. *current protein and peptide science*, 20(3), 277-284.

