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The Effect of Lawi-Lawi Grass (*Caulerpa racemosa*) on Blood Glucose Levels of *Rattus norvegicus*

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ABSTRACT

Lawi-lawi seaweed (Caulerpa racemosa) contains fibre and antioxidants, which are the largest components that can inhibit blood clotting and reduce blood sugar levels by slowing the release of glucose into the blood. This study aimed to determine the effect of giving Lawi-lawi seaweed (Caulerpa racemosa) on the blood glucose levels of male Wistar strain Rattus norvegicus. This research is pure experimental research, using a posttest-only control group design. The sample consisted of 25 male white rats weighing 150-200 grams. All rats were coded and then induced with alloxan at a dose of 130 mg/kg BW, if the rat's blood glucose level was > 200 then the rat was said to be diabetic, then the rats were randomly divided into 5 groups, negative control, positive control, treatment 1 (1.87g), treatment 2 (3.75g) and treatment 3 (5.62g) groups. The results of the post hoc test on the average change in blood glucose levels of rats for 30 days of treatment generally showed a value of $p = 0.000$, where $p < 0.05$ so that it could be interpreted that between the negative control group receiving standard feed treatment, the positive control group being given metformin, There were differences in changes in blood glucose levels in the treatment groups of seaweed at doses 1, 2 and 3 doses, meaning that there was an effect between the groups giving Lawi-lawi seaweed on reducing blood glucose levels of rats for 30 days of treatment.

Keywords: Diabetes mellitus; Lawi-lawi seaweed (*Caulerpa racemosa*); male white rat (*Rattus norvegicus*).

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INTRODUCTION

The epidemiological pattern of non-communicable diseases (NCDs) is becoming increasingly evident, primarily driven by behavioral changes within the population. These include unhealthy lifestyle practices, such as high consumption of junk food and fast food, intake of high-calorie and fatty foods, smoking, alcohol use, low dietary fiber intake, insufficient consumption of fruits and vegetables, and lack of physical activity (1–3). In Indonesia, fiber intake remains relatively low, contributing to the increasing incidence of various degenerative diseases, including diabetes mellitus (4–6).

Glucose serves as a vital carbohydrate that is predominantly absorbed into the bloodstream, with additional glucose synthesized in the liver through the conversion of other sugars. Diabetes mellitus is a metabolic disorder characterized by elevated blood glucose levels (hyperglycemia), resulting from a deficiency of the insulin hormone in the body (7–9). As the principal energy source for bodily tissues, glucose plays a crucial role in cellular energy production. Blood glucose concentration is strongly associated with the onset and progression of diabetes mellitus (10–12).

Changes over time have progressively influenced individuals' dietary patterns and lifestyle behaviors. In contemporary society, there is a growing tendency to consume high-fat foods, which contributes to the rising prevalence of degenerative diseases, including diabetes mellitus (13). This condition is characterized by elevated blood glucose levels (hyperglycemia) resulting from insufficient insulin production. When left unmanaged or undiagnosed, diabetes mellitus can lead to a range of serious and potentially fatal chronic complications (14).

The incidence of metabolic disorders such as diabetes mellitus has shown a significant upward trend, accompanied by increasing morbidity and mortality rates (15). According to the 10th edition of the 2021 report by the International Diabetes Federation (IDF), an estimated 537 million adults globally—or approximately 10.5% of the world's population—are living with diabetes mellitus. Over the past decade, Indonesia has consistently ranked among the top ten countries with the highest number of diabetes cases, reaching 19.5 million in 2021, with projections estimating an increase to 28.6 million by 2045 (16–18). Type 2 diabetes constitutes approximately 90% of all diabetes cases and is characterized by insulin resistance along with impaired function of pancreatic cells responsible for insulin secretion (19).

The results of Basic Health Research (Riskesdas) 2023 show that the prevalence of diabetes mellitus based on the results of measuring blood sugar levels has increased from 10.9% in 2018 to 11.7% in 2023. The highest prevalence of diabetes diagnosed by a doctor or symptoms is in DKI Jakarta ranks first out of all provinces in Indonesia, with the number of Diabetes Mellitus sufferers of 3.1% then followed by DI Yogyakarta at 2.9%, East Kalimantan at 2.3%, and North Sulawesi at 2.1% (20).

In an effort to reduce the high risk of diabetes, people with diabetes mellitus are recommended to pay attention to the intake of carbohydrates, protein, fat, and fibre because they are important in controlling blood glucose levels. However, there are people with diabetes mellitus who have been running a diet program who are still unable to control blood glucose properly so that their daily levels remain high; the cause is a lack of intake of fibre and antioxidant sources (21–23).

Seaweed is one of the foodstuffs that contains fibre and can be used as a main component in diet therapy for people with diabetes mellitus (24). The seaweed used in this study is the *Caulerpa Racemosa* type of seaweed, which is a group of green seaweed (Chlorophyceae) that is used by coastal communities as vegetables or as a complement to staple foods. Lawi-lawi seaweed (*Caulerpa racemosa*) has a high nutritional content as a source of vegetable protein, minerals, and vitamins. This type of seaweed contains 17-27% protein, 0.08-1.9% fat, 39-50% carbohydrates, 12.4% fibre, and 8.15-16.9% ash content and high-water content. 80-90%(25). The fibre contained in seaweed is an important compound that is useful for filling and facilitating the body's metabolic processes, reducing triglycerides (blood fats) and lowering blood sugar levels. When compared with foodstuffs derived from land plants (tubers, fruit, cereals, and nuts), the total fibre content of seaweed is relatively higher (26,27).

In this study, diabetes was induced in experimental animals. Rats (Rattus norvegicus) are commonly used in biomedical research due to the anatomical and physiological similarities of their organ systems, nutritional requirements, and metabolic processes to those of humans. They are particularly valuable for investigating complex pathological conditions such as hypertension and diabetes. Male rats are preferred over females because they exhibit a longer and more stable growth phase, minimizing hormonal variability that may affect experimental outcomes. Therefore, in this study, male white rats (Rattus norvegicus) were selected as experimental models to assess the effect of Lawi-lawi seaweed (Caulerpa racemosa) on blood glucose levels.

This study presents a novel contribution by specifically evaluating the hypoglycemic effect of *Caulerpa racemosa* (commonly known as lawi-lawi) harvested from the coastal waters of Punaga, Takalar Regency, South Sulawesi, on alloxan-induced diabetic *Rattus norvegicus*. To date, few local studies have investigated the antidiabetic potential of fresh *C. racemosa*, a seaweed traditionally consumed by coastal communities in Indonesia. Moreover, this study employs three distinct dosage levels and compares their effects with a positive control group receiving metformin, offering a comprehensive assessment of its dose-dependent efficacy. These findings provide valuable insights into the potential use of locally available seaweed as a functional food for supporting diabetes management.

METHOD

This research employed a pure experimental design using a post-test only control group method and was conducted over 40 days in the pharmacology laboratory. A total of 25 male Wistar rats aged 2–3 months and weighing 150–200 grams were used, adapted for 7 days prior to intervention. Diabetes was induced using alloxan at a dose of 130 mg/kg BW via intraperitoneal injection. Rats with blood glucose levels exceeding 200 mg/dL were considered diabetic and randomly assigned into five groups: negative control (standard feed only), positive control (metformin 500 mg), and three treatment groups receiving *Caulerpa racemosa* (lawi-lawi) seaweed at doses of 1.87 g, 3.75 g, and 5.62 g/day, respectively.

The seaweed utilized in this study was freshly collected from the coastal area of Punaga, thoroughly washed, blended, and filtered to produce an extract for oral administration. All experimental groups were provided with a standard diet of 15 g/day and unlimited access to drinking water (ad libitum). Blood glucose levels were assessed at three time points: baseline, post-alloxan induction, and after 30 days of treatment. Statistical analysis included paired t-tests for comparing pre- and post-treatment values, with One-Way ANOVA or Kruskal–Wallis tests applied based on the data distribution, followed by post hoc analysis to determine significant intergroup differences. Ethical clearance for this research was obtained from the Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Islam Negeri Alauddin Makassar (Approval No. A.059/KPEPK/FKIK/XI/2018).

RESULTS

Based on Table 1 shows that the blood glucose levels of rats during 30 days of treatment in the negative control group who received standard feed of corn grains of 15 grams/day and drinking was given ad-libitium experienced an average increase in blood glucose levels with an average difference of 106 mg/dl or an increase of 30.56%.

Table 1. Average Changes in Blood Glucose Levels Male *Rattus Norvegicus*

Group	Mean Blood Glucose			Difference	Percentage %
	Initial	Alloxan	30 Days Treatment		
Control (-) Feed Standard	98.75	346.75	452.75	106	30.56
Control (+) Metformin	103.75	508	156	-352	-69.29
Treatment 1 Dosage 1.87g	99.25	329.5	140.5	-189.	-56.87
Treatment 2 Dosage 3.75g	98.75	397.5	165.5	-232	-58.36
Treatment 3 Dosage 5.62g	90.25	494.75	150.5	-344.25	-69.56

Results on Post hoc average changes in rat blood glucose levels for 30 days of treatment generally showed a significant value with p value = 0.000, where p <0.05 so it can be interpreted that between the negative control group received standard feed treatment, the positive control group was given the drug metformin, the seaweed treatment group dose 1, dose 2 and dose 3 there was a significant difference in changes in blood glucose levels, meaning that there was an effect between the group giving Lawi-lawi seaweed on the decrease in blood glucose levels. rat blood glucose levels for 30 days of treatment.

While in the positive control group, the administration of metformin compared to the 3 treatment groups showed a p value > 0.05, so it can be interpreted that there is no significant difference in changes in blood glucose levels, meaning that in the treatment groups 1,2 and 3, it can match the decrease in blood glucose in the group. Positive control of metformin, which is useful for lowering blood glucose.

Table 2. Post Hoc Results from One-way ANOVA Test: Mean Changes in Blood Glucose Levels in Rats

Treatment	Groups Treatment Groups Comparison of	Probability Values of Mean Changes in Blood Glucose Levels in Rats
Negative Control	Positive Control	.000
	Treatment 1 RL 1.87g	.001
	Treatment 2 RL 3.75g	.000
	Treatment 3 RL 5.62g	.000
Positive	Control Negative	.000
	Treatment 1 RL 1.87g	.167
	Treatment 2 RL 3.75g	.660
	Treatment 3 RL 5, 62	1.000
Treatment 1 RL 1.87g	Negative Control	.001
	Positive Control	.167
	Treatment 2 RL 3.75g	1.000
	Treatment 3 RL 5.62	.215
Treatment 2 RL 3.75g	Negative Control	.000
	Positive Control	.660
	Treatment 1 RL 1.87g	1.000
	Treatment 3 RL 5.62g	.833
Treatment 3 RL 5.62g	Negative Control	.000
	Positive Control	1.000
	Treatment 1 RL 1.87g	.215
	Treatment 2 RL 3.75g	.833

Based on Table 2, the results of the test on the post hoc average change in rat blood glucose levels for 30 days The treatment in general showed a significant value with p value = 0.000, where p <0.05 so it can be interpreted that the negative control group received standard feed treatment, the positive control group was given the drug metformin, the seaweed treatment group dose 1, dose 2 and at dose 3 there was a significant difference in changes in blood glucose levels, meaning that there was an effect between the groups of giving Lawi-lawi seaweed on the reduction of blood glucose levels in rats for 30 days of treatment.

In the positive control group, the administration of metformin, when compared with the three treatment groups, resulted in a p-value > 0.05. This indicates that there were no statistically significant differences in blood glucose level changes between the treatment groups 1, 2, and 3 and the positive control group. Therefore, the reductions observed in the treatment groups were comparable to those achieved by metformin, which is known for its efficacy in lowering blood glucose levels.

DISCUSSION

Seaweed is one of the leading commodities that has the potential as a functional food. Seaweed is consumed as a vegetable or fresh vegetable by people in tropical areas such as Indonesia. Seaweed is rich in fibre, vitamins, and minerals and is a source of natural antioxidants that are easily obtained and available in large quantities.

The high fibre is due to the high polysaccharides in seaweed cells. The amount of crude fibre is the amount of dietary fibre and functional fibre. The habit of consuming fibre is very beneficial for humans who suffer from obesity and diabetes mellitus. The physicochemical properties of seaweed fibre are the same as those available in fibre-rich commercial foods (28). Therefore, this lawi-lawi seaweed can be used as a food that can lower blood glucose levels.

Alloxan can cause insulin-dependent Diabetes Mellitus in animals. This can be influenced by the working process of alloxan, and the negative control group did not get the same treatment as the other groups, so that their glucose levels increased (29) . The mechanism of action of alloxan has been studied thoroughly; several experimental studies have shown that alloxan evokes a sudden increase in insulin secretion after induction. The action of alloxan in the pancreas is initiated by its rapid uptake by pancreatic beta cells, which has been proposed to be one of the important features that can determine the diabetogenesis of alloxan. Alloxan has two major pathological effects: inhibiting glucose-induced insulin secretion through its ability to inhibit beta-cell glucose sensors. Second, it can cause pancreatic beta-cell damage as the result of hydroxyl radical reactions of alloxan with intracellular thiols, leading to pancreatic beta-cell necrosis and insulin-dependent alloxan (30).

Furthermore, the positive control group received standard feed of corn grains of 15 grams per day, and the administration of metformin, 500 doses of 45 mg/kg BW, and drinking was given ad libitum. The results showed that the blood glucose levels of rats during 30 days of treatment decreased. Metformin administration was able to reduce blood glucose levels by an average difference of 352 mg/dl, or a decrease of 69.29%.

The decrease in blood glucose levels in the positive control group rats with metformin administration could be caused by the specific mechanism of metformin in lowering blood glucose levels. Mechanisms of metformin in lowering blood glucose levels include direct stimulation of glycolysis in peripheral tissues by increasing the release of glucose in the blood, reducing hepatic gluconeogenesis, slowing glucose absorption from the blood, reducing plasma glucagon levels, and increasing insulin binding to insulin receptors. The mechanism of action of metformin in lowering blood glucose levels does not depend on the presence of pancreatic cell function (31,32).

Furthermore, the treatment group 1, a group of diabetic rats, was given standard feed as much as 15 grams/day and given a seaweed-lawi treatment dose of 1.87 grams/day, and the provision of drinking ad libitum. The results of this study indicate that the treatment group 1 experienced a decrease in blood glucose levels with an average difference of 177.8 mg/dl for 30 days of treatment, with a percentage of 56.87%.

Two treatment groups, ie, groups of diabetic rats, are given a standard feed as much as 15 grams/day and given a treatment lawi seaweed-lawi dose of 3.75 grams/day, and the provision of drinking ad-libitum decreased blood glucose levels greater than that of treatment 1. The average difference in the decrease was 232 mg/dl for 30 days of treatment, with a percentage decrease of 58.36%.

Treatment group 3, the group of diabetic rats given standard feed as much as 15 grams/day and given treatment with seaweed lawi-lawi at a dose of 5.62 grams/day as well as drinking ad-libitium decreased blood glucose levels with an average difference of decrease of 344.25 mg/dl for 30 days of treatment with a percentage of 69.56%. The decrease that occurred in treatment 3 was comparable to the decrease in the positive control group, which was given metformin.

Administration of Lawi-lawi seaweed resulted in a reduction of blood glucose levels across all treatment groups, with significantly lower levels compared to the group that received only standard feed. Seaweed is recognized as a dietary component with potential benefits for glycemic control. Multiple studies have demonstrated that individuals with diabetes mellitus who receive seaweed-based supplements experience reductions in blood glucose levels (33). Supporting this, Suter et al. (2015) reported that a combined diet of Eucheuma cottonii and soybean effectively reduced blood glucose levels in diabetes-induced experimental animals (34).

The research conducted by Nugroho *et al.* (2017) showed that the dose of Eucheuma sp. optimally at 1.5 g/kg BW caused a decrease in blood glucose levels of white rats by 23% (from 195.5 mg/dl to 150 mg/dl) (35), a study conducted entitled the effect of giving extract *Gracilaria verrusca* on the blood glucose levels of white rats *Rattus norvegicus* showed that the administration of extract *Gracilaria verrusca* could reduce blood glucose levels of white rats by 53.65% (from 245.98 mg/dl to 114 mg/dl) (24,36).

Grass Lawi-lawi sea (*Caulerpa racemosa*) is a type of seaweed from the class Chlorophyceae. Lawi-lawi seaweed is a seaweed that is often consumed as a vegetable and fresh vegetables in the tropical Pacific, especially in the Philippines and Indonesia. The high fibre content in seaweed can lower blood glucose levels. In addition, seaweed is rich in bioactive compounds in the form of polyphenols, vitamin carotenoids, phycobilins, phycocyanins, and polysaccharides, and many of them are known to have beneficial applications in human health. Elements needed for a healthy human diet can be found in seaweed. Edible seaweed is also low in calories and rich in dietary fibre, unsaturated fatty acids, and vitamins, which make it suitable for managing diabetes (26).

Dietary fibre has physiological functions that are important for body health. According to physical characteristics and their effects on the body, dietary fibre is divided into two groups: soluble dietary fibre and insoluble dietary fibre. The water-soluble dietary fibre groups are pectin, psilium, gum, mucilage, carrageenan, alginic acid, and agar, while those included in the water-insoluble dietary fibre group are cellulose, hemicellulose, and lignin. The presence of fibre in food can affect the GI value of food.

The mechanism of dietary fibre in influencing the GI value of a food is by reducing the efficiency of carbohydrate absorption, thereby inhibiting the rapid increase in blood glucose in the body. Dietary fibre that plays a role in this is soluble dietary fibre, such as pectin and guar gum. Various studies report that the consumption of dietary fibre has a positive effect on people with diabetes mellitus. Wannamethee *et al.*, (2009) reported that a diet containing low fibre (less than 20 g/day) significantly increased the risk of diabetes mellitus. On the other hand, it has been reported that a diet with a high fibre content is associated with a reduced risk of inflammation and can significantly improve glycemic control in patients with type 2 diabetes mellitus (38–41).

Furthermore, to see the provision of lawi-lawi seaweed which has the most effect on reducing blood glucose levels, it can be seen that the highest p-value is among the three treatment groups. The treatment group 1 had a p-value of .167, treatment 2 had a p-value of .660, and treatment 3 had a p-value of 1,000. It can be interpreted that the one with the highest p-value among the three groups is treatment group 3.

The conversion factor from rats to humans with a body weight of 70 kg for humans and an average rat body weight of 200 grams is 56. 0. The effectiveness of fibre requirements in rats is 5.62 x 56.0 (Conversion factor from rats to humans) = 314.72 g of fibre needed by humans. The effectiveness of fibre requirements in humans is given by 37.76 lawi-lawi seaweed with a fibre content of 314.72 grams.

CONCLUSIONS AND RECOMMENDATIONS

The results of the post hoc test on the average change in blood glucose levels of rats for 30 days of treatment generally showed a value of $p = 0.000$, where $p < 0.05$ so that it could be interpreted that between the negative control group receiving standard feed treatment, the positive control group being given metformin, There were differences in changes in blood glucose levels in the treatment groups of seaweed at doses 1, 2 and 3 doses, meaning that there was an effect between the groups giving Lawi-lawi seaweed on reducing blood glucose levels of rats for 30 days of treatment. It is necessary to study longer to get normal glucose levels in male rats of the Wistar strain Rattus norvegicus, which can be further investigated in humans to determine the effect of seaweed tail feather (Caulerpa racemosa) on lowering blood glucose levels.

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