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Obesity Model in White Male Wistar Rats: The Impact of Moringa (Moringa Oleifera) Flower Extract on Pancreatic Function as Deduced from Serum Amylase and Lipase Levels and the Histopathological Image of the Pancreas

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ABSTRACT

Diabetes and obesity go hand in hand. Antidiabetic drugs are effective in treating diabetes. However, currently available antidiabetic drugs are too expensive, do not work, and cause major side effects. A significant therapeutic option for Diabetes Mellitus and obesity is using bioactive chemicals produced by plants. This compound is efficacious, easily accessible, safe, and affordable. The main aim of this study was to determine whether pancreatic extract from Moringa oleifera flowers affected blood amylase and lipase levels, as well as the histological appearance, of obese male Wistar white rats (*Rattus norvegicus*). This is a True experimental study, with the research design used as a test control Group Design. The research data was then analyzed with the help of SPSS using ANOVA and Post Hoc Test with LSD technique. This researcher used 24 male rats. Treatment with Moringa oleifera flower extract improves pancreatic function in obese Wistar white rats by reducing serum lipase and amylase levels. The results of research on serum lipase and amylase levels showed that a dose of 600mg/Kg BW improved pancreatic function in white rats of the Wistar strain that were obese.

Keywords:

Obesity, Diabetes Mellitus, Moringa Oleifera, Serum Amylase Levels, Serum Lipase Levels

1. INTRODUCTION

Humans can't function well without food. Consuming a well-rounded diet is essential for obtaining energy. On the other hand, fast food is becoming increasingly popular due to its convenience for daily life. There are a lot of calories in fast food, but not many nutrients. It's heavy in sugar, refined carbohydrates, and sodium, lacking fiber and micronutrients [1]. Obesity is more likely to occur in those who engage in unhealthy eating behaviors [2].

Excess fat, or obesity, builds up in the subcutaneous tissues and then travels to other body parts, causing health problems. Malnutrition due to long-term overconsumption of unhealthy foods is the root cause of obesity, according to health experts. Health concerns are experienced by those who are overweight [3]. Year after year, more and more people are becoming overweight. The prevalence of obesity has increased, according to statistics from 2013 Basic Health Research. Obesity affects 32.9% of women, far more than the 19.7% of men. In 2018, Basic Health Research found that the adult obesity rate in Indonesia reached 21.8% [4].

A lack of physical exercise and caloric consumption is the root cause of obesity. The significant causes of obesity are probably an increase in calorie consumption and a decrease in physical activity. Diabetes and obesity go hand in hand. The inability of the body to control blood sugar levels in response to food intake, leading to diabetes (Type 2), is positively correlated with higher rates of obesity. Diabetes is more likely in people who are overweight. Although the prevalence of type 2 diabetes in teenagers is modest (0.25%), it was formerly virtually entirely diagnosed in adults. Adolescent obesity is associated with prediabetes, which is defined as high blood glucose levels below the diabetes diagnostic threshold [5].

Hyperglycemia and the associated dysfunction of carbohydrate, fat, and protein metabolism affect many body organs and disrupt their normal function [6]. This disorder develops gradually and arises primarily because of the

harmful effects of associated hyperglycemia on the standard structure and function of the micro and macrovasculature, which lie at the core of organ structure and function throughout the body. Structural and functional disorders of the vasculature of organ systems cause micro- and macrovascular complications [7], [8]. Organ damage, dysfunction, and, ultimately, organ failure characterize these complications and affect the body's organs, including, in particular, the eyes, kidneys, heart, and nerves. Eye-related complications result in retinopathy with progression to blindness. Kidney-related complications lead to nephropathy and potential kidney failure. Heart-related complications include hypertension and coronary heart disease. Nerve-related complications lead to neuropathy, which can be autonomic and peripheral. Cardiovascular, gastrointestinal, and genitourinary (including sexual) dysfunction are typical manifestations of autonomic neuropathy. At the same time, foot infections, including ulcers requiring amputation and Charcot joints (osteoarthropathy), are often associated with long-term peripheral neuropathy [9].

The pancreas, specifically its ß cells and a cell, is an organ that plays a role in the progression of diabetes mellitus [10]. When the body does not effectively use insulin, as happens when the pancreas generates insufficient insulin, the result is diabetes mellitus. Diabetes mellitus develops when the pancreatic β cells do not secrete enough insulin or peripheral tissues do not have enough insulin sensitivity or absorption. The worrisome rise in obesity rates can be attributed to modern lifestyle changes, particularly the abundance of food and the lack of exercise. In the long run, this way of living causes insulin resistance and obesity [11].

Antidiabetic medications effectively treat diabetes [12], [13]. However, current antidiabetic medications are too expensive, don't work, and cause significant adverse effects. Patients with diabetes who simultaneously suffer from renal, hepatic, or cardiac failure should not take the commonly prescribed oral antidiabetic medications biguanides, sulfonylureas, or thiazolidinediones. A significant therapy option for Diabetes Mellitus and obesity is using plant-bioactive chemicals. These compounds are efficacious, conveniently accessible, safe, and affordable [14]. Roglic suggests using medicinal herbs for diabetes mellitus [15].

An essential part of diabetes care is using medicinal herbs with antihyperglycemic effects [16]–[18]. Many classes of phytochemicals with antidiabetic effects have been identified and categorized according to distinctions in their chemical structures; these phytochemicals are found in medicinal plants. Plant chemicals can be classified into several broad groups: alkaloids, aromatic acids, carotenoids, coumarins, essential oils, flavonoids, glycosides, organic acids, phenols and phenolics, phytosterols, saponins, steroids, tannins, terpenes, and terpenoids. Vitamins and medicinal plants have recently been found to have anti-diabetic, anti-hyperglycemic, anti-lipidemic, hypoglycemic, and insulin-mimicking effects in pharmacological trials [19], [20]. Moringa oleifera is one plant that has the potential to treat diabetes.

The Moringa plant (*Moringa Oleifera*) is a medicinal plant in great demand because of its diverse biological properties. The evidence reviewed suggests the natural ability of this plant to protect against complications associated with heart disease, cancer, fatty liver, and diabetes mellitus [21]. For example, previously published reviews support the beneficial effects of *Moringa Oleifera* in improving blood glucose control in experimental models of diabetes [22].

This research examines the effects of a *Moringa oleifera* flower extract on pancreatic function, histopathology, and serum amylase and lipase levels in an obesity model using white male Wistar rats (*Rattus norvegicus*). After 14 days of treatment with 200, 400, or 600 mg/kg body weight of *Moringa oleifera* flower extract, the histological picture of pancreatic tissue in the obese white mice is shown.

2. METHOD

This study is a true experimental study, with the research design using a control group design, a type of research that only observes the control group and treatment after being given an action [23]. This research was carried out at the Laboratory of the Department of Pharmaceutical Pharmacology, Faculty of Medicine, University of North Sumatra, and Anatomical Pathology Laboratory, University of North Sumatra. The study was conducted from October to December 2023.

The research sample in this study was a white rat (*Rattus norvegicus*) male Wistar strain weighing 200-300 gr and aged 2-3 months. In this study, researchers used six Wistar rats for each experimental group, so the total number of test animals was 24 [24]. Grouping of test animals was carried out randomly into 4 test groups.

Simply put, a dependent variable is a product of an independent variable, which in turn influences or causes the dependent variable to appear. If an independent variable is present, it will affect or become a consequence of the dependent variable [25]. Variable independent: *Moringa Oleifera*, variable dependent: improvement of pancreatic function and its histopathological picture, precondition variables: high cholesterol diet to bring up obesity conditions, Precondition Variable: High cholesterol diet to cause obesity.

The research data was then analyzed with the help of SPSS (Statistic of Package for Social Science) 25.0. for windows. The data normality test was analyzed using the Kolmogorov-Smirnov Test approach ($p > 0.05$) [26]. To test the significance between groups, the trial was carried out with a one-way ANOVA analysis technique at a confidence degree of 95% ($p < 0.05$). Further analysis or tests are carried out using a Post Hoc Test with the LSD technique.

3. RESULTS AND DISCUSSION

Among the many things revealed by this study's findings are:

Table 1. Characteristics Test Animals

Component	Group			
	Control	**P1**	**P2**	**P3**
Types of Rats	*Rattus norvegicus* White Wistar Strains			
Gender	Male			
General circumstances	The coat color is white, healthy, and active.			
Average Initial Weight	242gr	239gr	245gr	264gr
Average Final Weight Loss	255gr	312gr	329gr	322gr

Before and after therapy, the rats were healthy, according to their features. Twenty-four test animals completed this investigation without dropping out. Twenty-four experimental animals were weighed. Table 2 shows the average body weight of each group before and after 14 days of treatment.

Table 2. Mouse Body Weight

Parameter	Group	Average a high-fat diet	
		Before	**After**
Weight (gr)	Control	243	255
	P1	239	312
	P2	245	329
	P3	264	322
Naso-length (mm)	Control	211	212
	P1	212	218
	P2	217	220
	P3	209	213
Lee Index	Control	0.29	0.29
	P1	0.29	0.31
	P2	0.28	0.31
	P3	0.29	0.32

Before the high-fat diet, test animals had a Lee index value of <0.3 or not included in obese circumstances [27]. After a high-fat meal, rats in treatment groups 1 and 2 had a Lee index of 0.31, and mice in group 3 had 0.32, indicating obesity. According to researchers, the treatment group's test animals were obese before Moringa flower extract was given.

Table 3. Lipase Up

No	Group	Repetition	Lipase Levels After a High-Fat Diet (U/L)	Lipase level after treatment (U/L)
1	Control	1st	21.4	21.6
2		2nd	22.2	22.5
3		3rd	21.6	22.1
4		4th	23.1	24.1
5		5th	23.4	24.7
6		6th	22.7	23.6
		Average	22.4	23.1
7	Treatment I (200mg/Kg BW)	1st	41.2	33.4
8		2nd	44.8	31.2
9		3rd	43.2	32.8
10		4th	40.8	30.4
11		5th	41.8	31.5
12		6th	43.2	32.1
		Average	42.5	31.9
13	Treatment II (400mg/Kg BW)	1st	42.9	28.1
14		2nd	41.2	29.1
15		3rd	43.9	26.3
16		4th	40.2	28.7
17		5th	41.5	26.1
18		6th	40.9	27.3

No	Group	Repetition	Lipase Levels After a High-Fat Diet (U/L)	Lipase level after treatment (U/L)
		Average	41.7667	27.6
19	Treatment III (600mg/Kg BW)	1st	42.8	20.9
20		2nd	43.1	23.1
21		3rd	41.9	22.6
22		4th	40.7	23.8
23		5th	41.8	24.6
24		6th	43.5	22.1
		Average	42.3	22.85

All groups revealed that lipase levels changed in the therapy group. The control group's average lipase level was 22.4U/L before treatment and 23.1U/L after 14 days of Aquades. Rat lipase levels in the control group are used to determine high and low levels in the treatment group. Treatment group 1 had lipase levels of 42.5U/L after a high-fat diet and 31.9U/L after 200mg/Kg BW moringa flower extract. Treatment group 2 became 27.6U/L following a high-fat meal of 41.76U/L with 400mg/Kg BW moringa flower extract. Finally, treatment group 3 became 22.85U/L after eating 42.3U/L of high-fat food and 600mg/Kg BW of moringa flower extract.

Researchers found that treatment group 3, obese mice administered *Moringa oleifera* extract at 600mg / Kg BW, had the most considerable lipase reduction and approached the control group. Treatment group 1, obese mice administered *Moringa oleifera* extract at 200mg / Kg BW, had the most minor lipase drop or improvement.

Table 4. Average Amylase Levels (U/L)

No	Groups	Repetition	Amylase Levels After High Fat Diet (U/L)	Amylase Levels after Treatment (U/L)
1	Control	1st	60.1	58.7
2		2nd	59.8	58.1
3		3rd	59.2	59.8
4		4th	60.6	59.1
5		5th	61.5	60.4
6		6th	60.6	59.3
		Average	60.3	59.2333
7	Treatment I (200mg/Kg BW)	1st	68.9	66.5
8		2nd	67.8	66.2
9		3rd	68.8	67.1
10		4th	69.4	68.8
11		5th	69.6	68.1
12		6th	68.1	67.4
		Average	68.7667	67.35
13	Treatment II (400mg/Kg BW)	1st	68.3	63.2
14		2nd	69.7	62.4
15		3rd	66.2	63.9
16		4th	67.6	62.6
17		5th	69.3	64.1
18		6th	66.3	64.6
		Average	67.9	63.4667
19	Treatment III (600mg/Kg BW)	1st	69.2	59.2
20		2nd	68.7	57.7
21		3rd	69.1	59.9
22		4th	67.3	58.7
23		5th	67.4	60.7
24		6th	69.5	58.2
		Average	68.5	59.1

All groups revealed that lipase levels changed in the therapy group. The control group's average lipase level was 22.4U/L before treatment and 23.1U/L after 14 days of aquades. Rat lipase levels in the control group are used to determine high and low levels in the treatment group. Treatment group 1 had lipase levels of 42.5U/L following a high-fat diet and 31.9U/L after 200mg/Kg BW moringa flower extract. After a high-fat diet of 41.76U/L and 400mg/Kg BW moringa flower extract, treatment group 2 became 27.6U/L. After a high-fat diet of 42.3U/L and 600mg/Kg BW, moringa flower extract, treatment group 3 reached 22.85U/L.

Researchers found that treatment group 3, obese mice administered Moringa Oleifera extract at 600mg / Kg BW, had the most considerable lipase reduction and approached the control group. Treatment group 1, obese mice administered *Moringa Oleifera* extract at 200mg / Kg BW, had the most minor lipase drop or improvement.

Table 5. Phytochemical Tests

Secondary Metabolites	Color	Result
Flavonoid	Red	+
Saponin	Yellow and foamy	+
Tannin	Greenish blue	+
Alkaloid	Yellow	+
Steroid	Green	+

The study conducted a phytochemical analysis of Moringa leaf and flower extracts and found the extract's content of saponins, alkaloids, and flavonoids.

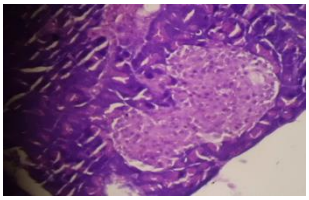
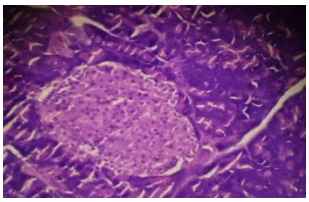
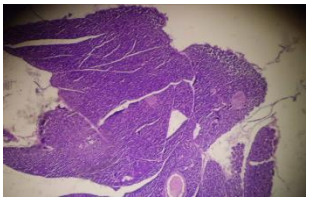
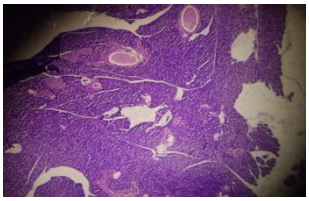
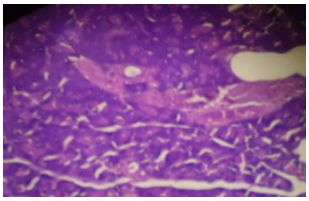
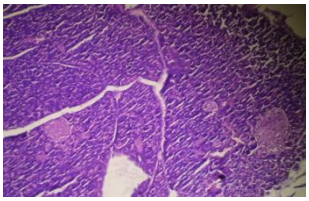
Histopathological observations were made using a light microscope with a magnification of 400x. This observation aimed to see the structure and morphology of cells in each pancreatic tissue specimen in the control and treatment groups given Moringa flower extract at 200mg/Kg BW, 400mg/Kg BW, and 600mg/Kg BW. *Moringa Oleifera* is delivered in the morning every day.

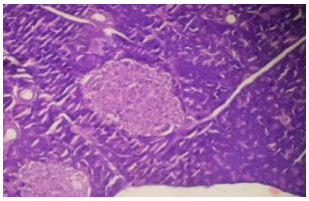
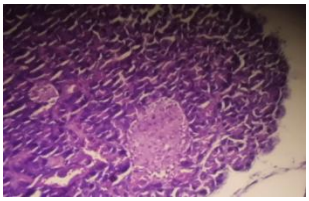
The cell morphology above shows variances across groups. The control group had normal pancreatic histology. Pancreatic histopathological observations in the control group show organs in standard form because they are not given a high-fat diet, so they can be used to describe other groups and be compared to the treatment group given a high-fat diet and *Moringa Oleifera* flower extract.

In treatment group 1, mice fed a high-fat diet and moringa flower extract at 200mg / Kg BB experienced changes in their pancreas organs' histological structure. Moringa flower extract at 400mg/Kg BW improved pancreatic histology in group 2. Treatment group 3, fed a high-fat diet and 600mg/Kg BW moringa flower extract, had pancreatic histology similar to the control group.

This study found that obese male white rats (*Rattus norvegicus*) Wistar strains receiving 600mg/Kg BW *Moringa Oleifera* extract improved pancreatic histology. Control and treatment group 3 pancreatic histopathological examinations show a similar morphology. Moringa flower extract compounds improve the histological structure of the pancreatic organs of obese white rats (*Rattus norvegicus*) male Wistar strains. Moringa flower extract at 600mg / Kg BW includes secondary metabolites that can heal cell tissue damaged by a high-fat diet and obesity in white rats (*Rattus norvegicus*) Wistar strains.

Table 6. Histopathological Features of Skin Tissue

No	Groups	Histopathological Image of Pancreatic Tissue	
1	Control (Aquades)		
2	Treatment 1 (200mg/Kg BW)		
3	Treatment 2 (400mg/Kg BW)		

4	Treatment 3 (600mg/Kg BW)		

Results of Observation of Serum Lipase Levels

Kolmogorov-Smirnov normality tests show that P-values > 0.05 suggest typically distributed data and vice versa [26]. The significance level was 0.200 for all groups. A p-value > 0.05 indicates regularly distributed data. This implies that the data is regularly distributed. After the data is normally distributed, the Levene test determines if each variety of this study population group is homogeneous. The following table shows this study's data normality test results:

Table 7. Serum Lipase Level Normality Test

Group Extract Dose	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control (C)	.189	6	.200*	.948	6	.721
Treatment P1	.142	6	.200*	.985	6	.973
Treatment P2	.185	6	.200*	.923	6	.529
Treatment P3	.115	6	.200*	.995	6	.998

Group homogeneity was tested using the Levene test with a 5% significance level. A significance value of < 0.05 indicates non-homogeneity for decision-making, whereas > 0.05 indicates homogeneity [26]. The Levene homogeneity test findings are in the table above. The probability in the significance column is 0.951. Since the significant probability value is greater than 0.05, the control group, treatment group 1, treatment group 2, and treatment group 3 come from homogeneous populations.

Table 8. Homogeneity Test Results for Serum Lipase Levels

	Levene Statistical	df1	df2	Sig.
Base on Mean	.114	3	20	.951
Base on Median	.112	3	20	.952
Based on the Median & the adjusted df	.112	3	17.642	.952
Based on trimmed mean	.114	3	20	.951

Table 9. One-Way ANOVA Test Results for Serum Lipase Levels

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	331.061	3	110.354	74.526	.000
Within Groups	29.615	20	1.481		
Total	360.676	23			

Table findings indicate a significant value of 0.000 or < 0.05 for the One-Way ANOVA test [26]. These statistics show substantial differences between the control and treatment groups. Average lipase levels were compared between groups using post-hoc LSD follow-up testing. A significance value below 0.05 indicates a significant difference between groups and vice versa. The table shows post-hoc LSD follow-up test results:

Table 10. Post-Hoc LSD Test Results for Serum Lipase Levels

Experimental Group (I)	Experimental Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control (Aquades)	Treatment P1	-8.80000*	.70255	.000	-10.2655	-7.3345
	Treatment P2	-4.50000*	.70255	.000	-5.9655	-3.0345
	Treatment P3	.25000	.70255	**.726**	-1.2155	1.7155
Treatment 1 (200mg/Kg BW)	Control (C)	8.80000*	.70255	.000	7.3345	10.2655
	Treatment P2	4.30000*	.70255	.000	2.8345	5.7655
	Treatment P3	9.05000*	.70255	.000	7.5845	10.5155
Treatment 2	Control (C)	4.50000*	.70255	.000	3.0345	5.9655

Experimental Group (I)	Experimental Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
(400mg/Kg BW)	Treatment P1	-4.30000*	.70255	.000	-5.7655	-2.8345
	Treatment P3	4.75000*	.70255	.000	3.2845	6.2155
Treatment 3 (600mg/Kg BW)	Control (C)	-.25000	.70255	.726	-1.7155	1.2155
	Treatment P1	-9.05000*	.70255	.000	-10.5155	-7.5845
	Treatment P2	-4.75000*	.70255	.000	-6.2155	-3.2845

*. The mean difference is significant at the 0.05 level.

To find out if the two groups are significantly different from each other, researchers utilize the LSD Post Hoc Test. The study revealed that treatment groups 1 and 2 differed significantly from the control group (p=0.000 and p=0.000, respectively), but treatment group 3 did not differ significantly (p=0.726).

Results of Observation of Serum Amylase Levels

Table 11. Serum Amylase Level Normality Test

Group Extract Dose	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control (C)	.134	6	.200*	.996	6	.998
Treatment P1	.146	6	.200*	.966	6	.862
Treatment P2	.190	6	.200*	.939	6	.652
Treatment P3	.130	6	.200*	.979	6	.946

A significance level of 0.200 was achieved in all groups according to the findings of the normalcy test, which was conducted using the Kolmogorov-Smirnov Test. If the p-value exceeds 0.05, we say the data follows a normal distribution. The data is thus assumed to follow a normal distribution. After confirming that the data follows a normal distribution, the next step in checking for homogeneity is to use the Levene test to see if all of the subsets of the study population are similar.

The homogeneity test results using the Levene test can be seen in the table above. The probability value in the significance column is 0.824. The significance probability value obtained is more significant than 0.05, so it can be concluded that the control group, treatment group 1, treatment group 2, and treatment group 3 come from populations with the same variance or are homogeneous.

Table 12. Homogeneity Test Results for Serum Amylase Levels

	Levene Statistical	df1	df2	Sig.
Base on Mean	.301	3	20	.824
Base on Median	.290	3	20	.832
Based on the Median & the adjusted df	.290	3	18.120	.832
Based on trimmed mean	.301	3	20	.824

Table 13. One-Way ANOVA Test Results for Serum Amylase Levels

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	280.325	3	93.442	103.737	.000
Within Groups	18.015	20	.901		
Total	298.340	23			

The significant value produced by the One-Way ANOVA test is 0.000, which is less than 0.05, as seen in the previously provided table. It is clear from these numbers that the treatment group differs significantly from the control group. To investigate potential variations in mean amylase levels between categories, we ran the post hoc LSD additional test. The following table displays the outcomes of the post-hoc LSD further test:

Table 14. LSD Post-Hoc Test Results for Serum Amylase Levels

Experimental Group (I)	Experimental Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control (Aquades)	Treatment P1	-8.11667*	.54795	.000	-9.2597	-6.9737
	Treatment P2	-4.23333*	.54795	.000	-5.3763	-3.0903
	Treatment P3	.16667	.54795	**.764**	-.9763	1.3097
Treatment 1 (200mg/Kg BW)	Control (C)	8.11667*	.54795	.000	6.9737	9.2597
	Treatment P2	3.88333*	.54795	.000	2.7403	5.0263
	Treatment P3	8.28333*	.54795	.000	7.1403	9.4263
Treatment 2 (400mg/Kg BW)	Control (C)	4.23333*	.54795	.000	3.0903	5.3763
	Treatment P1	-3.88333*	.54795	.000	-5.0263	-2.7403
	Treatment P3	4.40000*	.54795	.000	3.2570	5.5430
Treatment 3 (600mg/Kg BW)	Control (C)	-.16667	.54795	.764	-1.3097	.9763
	Treatment P1	-8.28333*	.54795	.000	-9.4263	-7.1403
	Treatment P2	-4.40000*	.54795	.000	-5.5430	-3.2570

*. The mean difference is significant at the 0.05 level.

If there were statistically significant differences in amylase levels across groups, the LSD Post Hoc Test was employed to find them out. The study revealed that treatment groups 1 and 2 differed significantly from the control group (p=0.000 and p=0.000, respectively), but treatment group 3 did not differ significantly (p=0.764).

Discussion

A model of obesity, white male Wistar rats (*Rattus norvegicus*) were used in this study to examine the effects of moringa flower extract (*Moringa Oleifera*) on pancreatic function, serum amylase and lipase levels, and histopathological image. This research used male Wistar white rats (*Rattus norvegicus*) weighing 200-300 g and two to three months old as samples. There were 24 mice, each group comprising four individuals whose samples were determined using the Ferderer formula. The first set of mice served as a control, receiving nothing more than ordinary pellets and purified water. A high-fat meal and varying amounts of Moringa flower extract (200, 400, and 600 mg/kg body weight) were administered to the treatment group.

Obesity is characterized by the abnormal buildup of fat cells in adipose tissue and their subsequent dissemination to other organs and tissues throughout the body. Malnutrition due to long-term overconsumption of unhealthy foods is the root cause of obesity, according to health experts. Obese people experience health issues. Another risk factor for diabetes is being overweight or obese [3]. There is a favorable correlation between the prevalence of obesity and diabetes, which occurs when the body fails to appropriately respond to food consumption by regulating blood sugar levels through insulin.

The pancreas, specifically its ß and cells, plays a role in developing type 2 diabetes and obesity [10]. Pancreatic damage occurs when excess fat is in the body, caused by eating unhealthy foods and not getting enough exercise. Taking antidiabetic medications can alleviate this issue. However, current antidiabetic medications are too expensive, don't work, and cause significant adverse effects. A vital therapy option for Diabetes Mellitus and obesity is using bioactive chemicals produced by plants. These compounds are efficacious, conveniently accessible, safe, and affordable [28]. *Moringa oleifera* is one plant that has the potential to treat diabetes. Researchers have hypothesized that obese male Wistar white rats (*Rattus norvegicus*) may benefit from pancreatic function enhancement when given moringa flower extract (*Moringa Oleifera*). Researchers performed experiments on male Wistar white rats (*Rattus norvegicus*) to validate this suspicion.

To start, the animals were given a high-fat diet as a preconditioning treatment to make them overweight. For fourteen days, quail egg yolks constituted the high-fat diet. The Lee Index is utilized to confirm that mice are fat. To establish whether the mice were obese, their weight and nasoanal length were measured again after being fed a high-fat diet. The mice in treatment groups 1.2 and 3 were classified as obese based on their Lee index values of 0.31 and 0.32 after ingesting a high-fat diet. After that, the test animals were treated with *Moringa oleifera* flower extract based on the dosage for each group.

After 14 days of data collection, processing, and analysis, it was time to run the numbers through a battery of tests for normality, homogeneity, and significance. Using SPSS and the Kolmogorov-Smirnov test, we got data that passed the normalcy test. So, in all the groups that tested blood lipase and amylase levels, the findings followed a normal distribution with a significance level of 0.200. Thus, the data can follow a normal distribution or represent the population.

The next step is to use the Levene test to check if the normally distributed data represents a normally distributed population with the same variance. The acquired data demonstrated that the significance value for amylase levels was 0.824, and for lipase levels was 0.951. Since the calculated significant probability value is more than 0.05, we can infer that the three treatment groups' lipase and amylase level observations represent similar populations. Next, the

One-Way ANOVA test was used to check for effectiveness and significance with this homogeneous and normally distributed data.

The significant value of the findings of the One-way ANOVA test on the results of observing the levels of lipase and amylase was 0.000, which is greater than 0.05. These results suggest that the control, treatment 1, and therapy three groups differ significantly from one another, necessitating a post hoc LSD test for further analysis. To compare the groups' average total cholesterol levels, researchers used a post hoc LSD test.

A significant difference was seen between the control group and treatment groups 1 and 2 (p=0.000) according to the Post Hoc LSD test analysis of lipase levels. In contrast, no significant difference was found with treatment group 3 (p=0.726). The results show that the lipase levels of the control group and the third treatment group, which received 600 mg/Kg WB of Moringa flower extract, were similar. Levels were different between the control group and treatment groups 1 and 2.

Analysis using the Post Hoc LSD test on amylase levels showed that treatment groups 1 and 2 differed significantly from the control group (p=0.000 and p=0.000, respectively), whereas treatment group 3 did not change significantly (p=0.764). The results show that the amylase levels in the third treatment group, which received 600 mg/Kg BW of Moringa flower extract, were similar to those in the control group. Levels were different between the control group and treatment groups 1 and 2.

Following the management of data on blood lipase and amylase levels in rats, histopathological pictures of pancreatic tissue from rats treated for 14 days were used for microscopic examinations. The results of the cell morphology analysis show that the categories are distinct. The pancreatic histology of the control group was expected. The control group's pancreatic histopathology observation results were utilized to describe and compare other groups.

A change in shape was observed in the pancreas of the rats in treatment group 1, which received a high-fat meal and 200 mg/kg body weight of Moringa flower extract. This change in shape was caused by the histological changes brought about by the rats' exposure to the high-fat diet. Histological changes in the pancreas improved in the second treatment group that received 400 mg/Kg BW of Moringa flower extract. The histological structure of the pancreas was similar to that of the control group in treatment group 3, which received a high-fat diet in addition to 600 mg/kg body weight of Moringa flower extract.

This study's findings suggest that obese male Wistar white rats (*Rattus norvegicus*) can benefit from a 600 mg/KgBW dose of *Moringa oleifera* flower extract by improving their pancreatic histological structure. Histopathological examinations of the pancreas in the third treatment and control groups show they are structurally similar. There is no way to disentangle the beneficial effects of *Moringa oleifera* flower extract from the fact that it improves the histological structure of the pancreas in obese male Wistar white rats (*Rattus norvegicus*). This is because white rats of the Wistar strain may heal cell tissue damage caused by a high-fat diet and obesity when given 600 mg/Kg BW of Moringa flower extract, which includes secondary metabolites.

An agent that helps repair pancreatic function that is compromised owing to obesity and a high-fat diet is found in the secondary metabolite content of *Moringa oleifera* flower extract, which includes tannins, alkaloids, flavonoids, and steroids. A prior study shows flavonoids promote pancreatic healing and suppress beta-cell apoptotic signals [29]. Choi et al. (2017) discovered that the saponins in Moringa flower extract aid in suppressing pancreatic cell death and reducing lipid characteristics [30].

4. CONCLUSION

Treatment with moringa flower extract (*Moringa oleifera*) improves pancreatic function in obese white Wistar rats (*Rattus norvegicus*) by lowering serum levels of lipase and amylase. By observing serum lipase and amylase levels that are comparable to those of the control group, it is evident that administering moringa flower extract (*Moringa oleifera*) at a dose of 600mg/Kg BW improves pancreatic function in obese Rattus norvegicus rats. By preventing the death of pancreatic cells, the secondary metabolites found in Moringa flower extract (*Moringa oleifera*) aid in the repair of pancreatic cells damaged by obesity. Comparing the control and treatment groups using histological pictures of pancreatic tissue revealed notable differences. Group 3 (600 mg/kg body weight) showed the most significant improvement in the histological appearance of pancreatic tissue and was most similar to the reference group (control) compared to the other groups.

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