Library Progress International
Vol.44 No.3, Jul-Dec 2024: P.7447-7464

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

A Study On Effect Of Probiotic Fermented Tea On Type II Diabetic Subjects

Zoya Nureen[1], S. Satyanarayana Singh[2], Srinivas More[3]

[1]Research Scholar, Osmania University, Hyderabad
[2]Professor, Dept of Biochemistry, Osmania University, Hyderabad
[3] MD zoy multispecility hospital, Zoyanureen001@gmail.com

How to cite this article: Zoya Nureen, S. Satyanarayana Singh, Srinivas More (2024) A Study On Effect Of Probiotic Fermented Tea On Type II Diabetic Subjects. *Library Progress International,* 44(3), 7447-7464.

ABSTRACT

This research examines the impact of Kombucha tea supplementation on individuals with type 2 diabetes, particularly emphasizing essential health metrics such as liver function, lipid profiles, and blood glucose levels. Changes in metabolism are frequently linked to type 2 diabetes, which can result in problems like hyperglycemia, dyslipidemia, and hepatic impairment. It has been proposed that the bioactive ingredients in kombucha tea, a fermented beverage high in microbes, antioxidants, and organic acids, provide health advantages. In this study, blood glucose levels, lipid profiles (including total cholesterol, triglycerides, LDL, and HDL), and liver function tests (including ALT, AST, and ALP) were tracked in diabetic participants who took Kombucha tea supplements for a predetermined amount of time. The gathered data were put through a thorough statistical analysis to determine the importance of any changes. The outcomes highlighted the potential benefits of Kombucha tea in treating metabolic diseases linked to type 2 diabetes by showing improvements in lipid metabolism, liver enzyme activity, and blood glucose management. According to these results, kombucha tea may be used with a diabetic's diet to help reduce the risk of problems. Confirming the long-term advantages and underlying mechanisms requires more research.

Keywords: Kombucha tea, Type 2 Diabetes, Blood Glucose Levels, Lipid Profile, Liver Functioning Test

Introduction

A symbiotic culture of bacteria and yeast is used in the fermentation process to make Kombucha (SCOBY). Since sweetened tea provides the substrate for fermentation, it is typically the initial step. Research indicates that the time and conditions during fermentation significantly impact the final product's flavour, acidity, and probiotic content (Czarnecki et al., 2024). In individuals with type 2 diabetes, kombucha intervention has been shown to enhance gut microbiota, reduce inflammation, and increase insulin sensitivity (Xu et al., 2022). Studies have shown that consuming Kombucha can considerably reduce postprandial hyperglycemia, suggesting that it could be a therapeutic option for type 2 diabetes patients to control their blood sugar levels. In prediabetic people who take supplements, probiotics have also been demonstrated to reduce HbA1c, triglycerides (T.G.), total cholesterol (T.C.), and low-density lipoprotein cholesterol (LDL-C). These results highlight the potential advantages of probiotics in lipid profile and blood sugar regulation. These findings suggest that taking probiotic supplements or eating fermented foods like probiotic curd may improve overall metabolic health and help regulate blood sugar levels (Li et al., 2022).

Research has shown that utilizing Kombucha as a treatment can reduce blood sugar levels and that the tea's length of fermentation plays a significant role in this hypoglycemic impact (Setiani et al., 2019). By offering an additional treatment approach, probiotics can help individuals with diabetes and prediabetes improve their lipid indicators, insulin sensitivity, and blood glucose levels. According to Fatima et al. (2024), this implies that probiotics might be a helpful addition to diabetes care strategies. Probiotics have been shown in numerous trials to enhance lipid profiles. A lipid profile is vital for assessing cardiovascular risk and metabolic health since it measures several lipids in the blood, such as cholesterol and triglycerides. Genetics, age, health conditions, lifestyle choices, and eating habits can impact lipid profiles, especially when managing diabetes (Rojo-López et al., 2024). Studies have shown that probiotic supplements increase HDL levels and decrease LDL, triglycerides, and total cholesterol (Colón et al., 2023).

This study looks at the effects of probiotic supplements on tea fermentation on type II diabetics' blood glucose levels. By combining the health benefits of tea with probiotics, this study seeks to elucidate the potential of this novel treatment approach in regulating hyperglycemia and improving metabolic outcomes in patients with type 2 diabetes. This study also focuses on a lipid profile to assess triglycerides, cholesterol, HDL, VLDL, and LDL, in addition to a liver functional test. Statistical analysis is then performed to determine the benefits of probiotic kombucha drinks for diabetes patients.

Methodology

Ethical clearance is obtained from the institute to investigate the impact of probiotic fermented tea on blood glucose, serum lipids, and lipoproteins in Type-II diabetic participants. A sample of sixty participants, aged twenty to fifty, will be chosen following the inclusion and exclusion criteria. The diabetic subjects will be chosen from the ZOI hospital's outpatient department. The study was designed to maintain the inclusion and exclusion criteria of the patients. The chosen patients are split into two groups to make the feeding experiments easier. Thirty subjects are part of the experimental group that receives supplements, whereas 30 subjects are part of the control group that does not receive supplements and is utilized in studies that compare the experimental group to the control group. The permission form will be obtained from willing participants once they are informed in plain terms about the study's purpose.

Thirty individuals were selected for a three-month (90-day) supplementation period. Thirty diabetic controls, thirty experimental, and one control group. We conducted biochemical analyses at 0, 30, 60, and 90-day intervals. Every day, 100 millilitres were given to the experimental groups. Other drinks are given to the control group. Weekly sample collection, monthly blood examinations, and dietary assessments were carried out. Details about the hospital's 24-hour diet recall are in a personalized diet chart with suggestions and guidelines for each visit.

Lipid Profile

The Roche Kit and the CHOD-POD method estimate cholesterol on a C6000 analyzer. Hydrolyzing the cholesterol esters in the presence of cholesteryl ester hydrolase yields fatty acids and cholesterol. Triglyceride is determined using a Roche kit and the GPO-PAP method on a C6000 analyzer. The immunological method of the C6000 analyzer and the Roche kit estimate HDL cholesterol. This method analyzes serum HDL directly without first separating the HDL-containing fraction. The automated method for directly assessing LDL cholesterol requires the selective solubilization of LDL cholesterol. The conversion factors are mg/dl x 0.0259-mmol/L and Mmol/Lx38.66 mg/dl.

Results

There are 60 participants in the study, 30 of whom are in the experimental group and the remaining 30 in the controlled group.

S.No	Pre-Supplementation	30 Days	60 Days	90 Days
1	158	150	142	135
2	156	150	140	131
3	155	151	139	132
4	152	148	138	130
5	143	140	131	124
6	142	138	130	121
7	133	128	120	112
8	150	145	136	129
9	147	142	133	127
10	136	131	123	117
11	143	139	131	123
12	152	145	139	130
13	152	148	138	129
14	157	153	143	136
15	154	148	129	119
16	155	150	140	133
17	157	150	141	134
18	158	152	145	137
19	147	141	135	128
20	145	140	130	121
21	145	139	128	120
22	157	148	140	132
23	159	152	146	137
24	158	150	142	135
25	154	149	140	131
26	155	150	142	133
27	155	149	137	129
28	157	152	138	127
29	153	148	139	130
30	152	147	137	127

Table 1: Control Group

The control (standard drink) and experimental groups' blood glucose levels were monitored before starting the probiotic drink and before the patients received the supplement. After that, the patient's blood glucose levels were monitored every 30 days until the end of the 90 days. The results mentioned in the table show that blood glucose levels decrease and become standard at the end of 90 days.

S.No	Pre-Supplementation	30 Days	60 Days	90 Days
1	154	130	109	99
2	159	131	110	95
3	154	132	108	98
4	151	128	107	96
5	153	129	112	97
6	152	128	104	99
7	153	130	107	89
8	150	133	113	88
9	157	130	111	85
10	156	128	110	84
11	153	127	113	99
12	152	129	112	84
13	152	128	114	86
14	152	131	109	97
15	152	128	110	95
16	156	134	108	94
17	157	130	107	91
18	158	132	109	83
19	157	133	112	86
20	155	134	106	87
21	155	132	112	98
22	157	129	106	97
23	156	127	107	89
24	156	130	109	87
25	154	128	102	88
26	155	129	103	82
27	152	127	101	81
28	154	126	108	90
29	153	125	110	97
30	153	122	106	96

Table 2: Experimental Group

Prior to starting the kombucha supplementation, the blood glucose levels of the experimental and control groups were comparable, indicating that both groups started from a similar baseline. This means that any changes observed beyond this point can be attributed to the effects of the Kombucha. After 30 days, the blood glucose levels in the control group dropped marginally to 145.7, which could have been the consequence of natural changes or placebo effects. Nevertheless, the experimental group—which drank Kombucha—exhibited a significant drop to 124, suggesting that Kombucha may have started positively impacting glucose regulation early in the supplementation stage. After 60 days, the experimental group's glucose levels dropped even lower to 108.5, whereas the control group's slightly declined to 136.4.

Table 3: Mean Values of Controlled and Experimental Groups

Test	Pre Supplementation		30 days		60 days		90 days	
	Cntrld	Exprmntl	Cntrld	Exprmntl	Cntrld	Expmntl	Cntrld	Exprmntl
Mean	152.23	154.20	145.7	124	136.4	108.5	128.3	91.23
S.D	6.78	2.26	6.17	3.66	6.25	5.79	6.26	5.91
SE	1.24	0.41	1.13	0.67	1.14	1.06	1.14	1.08

This significant decline in the experimental group implies that Kombucha may have a cascading effect that enhances insulin sensitivity and contributes to better blood glucose regulation over time. The probiotics in Kombucha most likely generate this effect. After 90 days, the blood glucose levels in the experimental group fell precipitously to 91.23, whereas the levels in the control group fell to 128.3. This demonstrates that consuming Kombucha over a protracted period lowered blood glucose levels significantly and persistently. The experimental group's mean blood glucose level was 91.23, which may indicate that many people had achieved a healthier range.

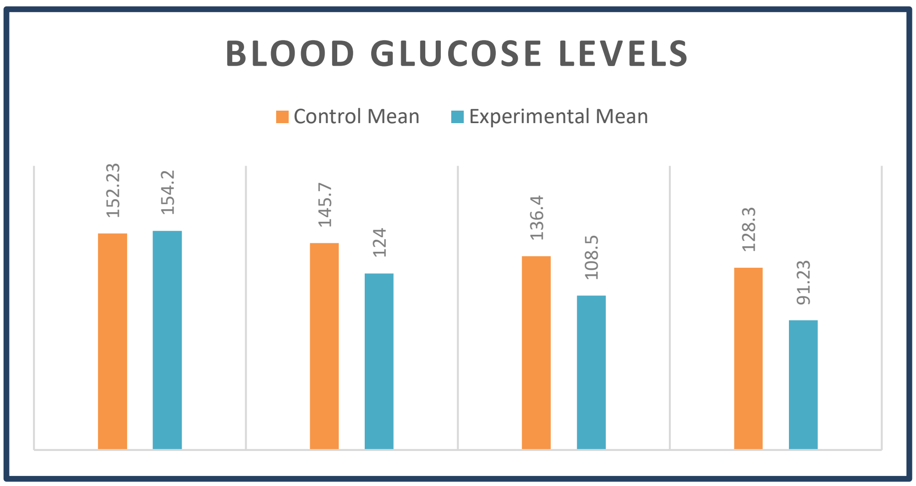

Fig 1: Blood Glucose Levels

The experimental group's S.D. values are consistently lower than the control group's, particularly at 60 and 90 days (3.66 and 5.79, respectively). This shows that the experimental group's blood glucose levels fluctuated less and became more stable, possibly due to the effects of supplementation. The S.E. of the experimental group is always lower, particularly once supplementation begins. For example, the control group's S.E. at 60 days is 1.14, but the experimental group's is 0.64. This implies that the experimental group's mean blood glucose levels are a more reliable and accurate representation of the population mean. The mean results showed that the experimental group's glucose levels were considerably lower than the control group's. The fact that the experimental group's standard deviation and standard error were lower indicates even more that the results were more reliable and consistent within this group. The experimental group significantly outperformed the control group, indicating that the supplementation successfully lowers blood glucose levels, especially over prolonged periods.

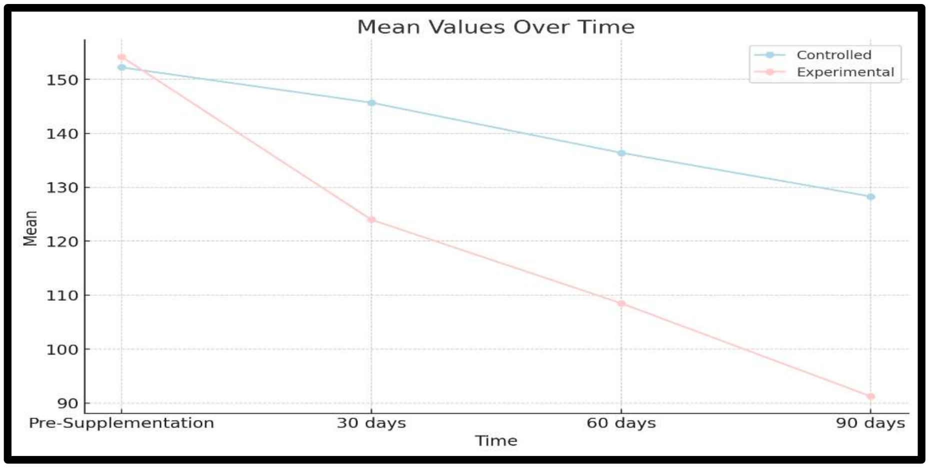

Fig 2: Mean Values over time

The high t-value (38.48) implies that the probiotic Kombucha significantly lowered blood glucose levels within 30 days, indicating the statistical significance of the difference. This difference shows that probiotic Kombucha has a sustained, significant effect on reducing blood glucose levels over a lengthy time (t-value of 40.22, statistically significant). After 90 days, the blood glucose levels in the experimental group were 62.97 units lower than those in the control group (Mean Difference: 62.97).

Time Point	Mean difference		Standard Deviation		T-test		Paired t-test	
	Cntrld	Exprtl	Cntrld	Exprtl	Cntrld	Exprtl	Cntrld	Exprtl
Pre-Supplementation vs. 30 Days	6.53	30.20	9.17	4.30	3.90	38.47	4.80	38.48
Pre-Supplementation vs. 60 Days	15.83	45.70	9.22	6.22	9.40	40.24	9.40	40.22
Pre-Supplementation vs. 90 Days	23.93	62.97	9.23	6.33	14.20	54.49	14.20	54.45

Table 4: Mean Difference

The t-value of 54.45 indicates that the difference is statistically significant, demonstrating probiotic Kombucha's robust and long-lasting effect on blood glucose regulation. The mean differences show that the probiotic Kombucha-consuming experimental group had considerably lower blood glucose levels than the non-kombucha-consuming control group.

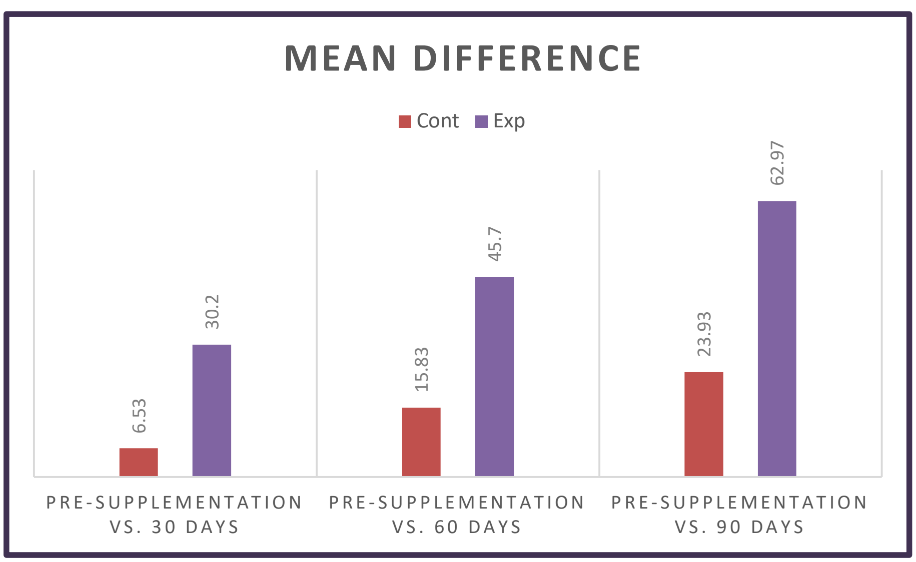

Fig 3: Mean Difference

The T-test results, ranging from 3.9 to 38.47, show the statistical significance of the reductions of blood glucose from pre-supplementation to each subsequent time point. A far higher level of statistical significance is demonstrated, with T-test values ranging from 9.4 to 40.24. This suggests that the blood glucose level drops in the experimental group are noticeably more pronounced than in the control group.

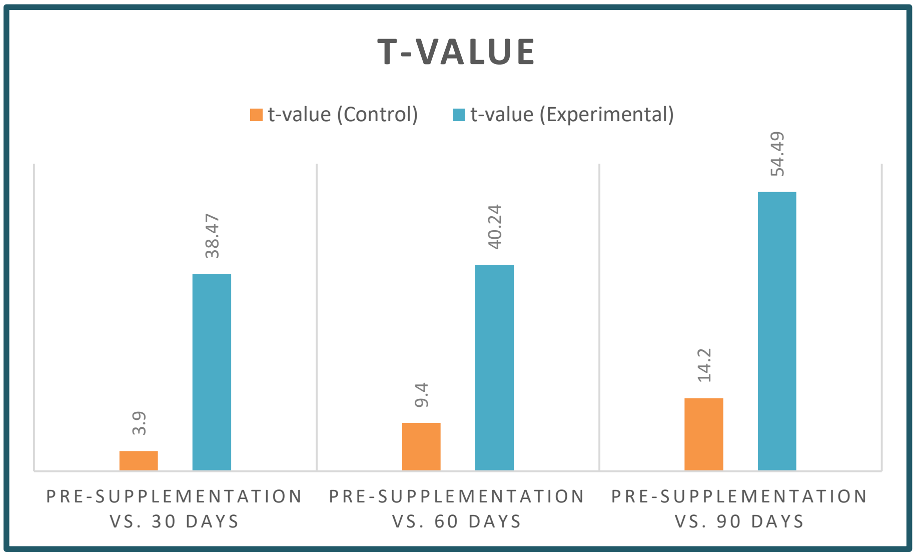

Fig 4: T-Value

After ninety days, the experimental group's blood glucose levels are 62.97 units lower than the control group's. This suggests that over time, Kombucha has an even more pronounced effect. The result of the paired t-test is 54.45. In this instance, the high t-value indicates a statistically significant difference, indicating that Kombucha has a consistent and progressively rising effect on blood sugar levels. The paired t-test data show that probiotic Kombucha consistently and significantly lowers blood glucose levels compared to the control group at all periods.

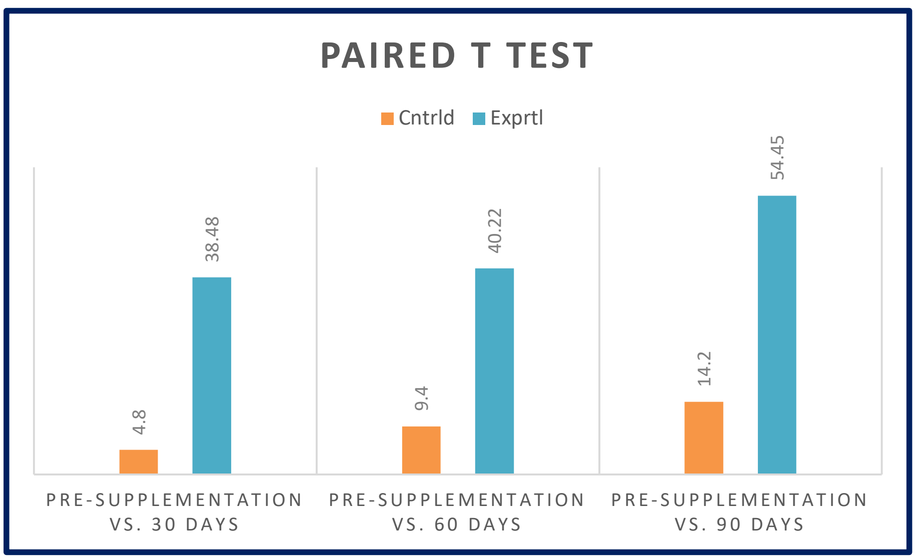

Fig 5: Paired T Test

Lipid Profile

Thirty of the sixty individuals in the study were assigned to the experimental group and the other thirty to the control group. A probiotic drink was administered to thirty subjects, and the results were compared to the prior measurement. Important information about how a particular intervention or treatment affects lipid levels in the blood can be found in the results of a controlled group's lipid profile, which include pre-and post-intervention values for total cholesterol, LDL cholesterol, HDL cholesterol, VLDL cholesterol, and triglycerides. The experimental group that consumed probiotics showed lipid profile results that clarified the impact of probiotics on lipid metabolism. Triglycerides, total cholesterol, LDL cholesterol, HDL cholesterol, and VLDL cholesterol pre- and post-consumption levels are included in the data. The results will be compared to those of the control group.

S.No	Cholesterol Mg/dl		LDL Mg/dl		HDL Mg/dl		VLDL Mg/dl		Triglycerides Mg/dl	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	175	171	123	110	48	53	38	32	180	168
2	200	194	88	82	49	52	39	29	159	142
3	185	179	106	99	50	54	40	31	156	142
4	164	158	105	100	55	60	35	30	121	118
5	188	177	143	120	50	55	31	29	103	90
6	205	196	119	108	57	60	42	30	117	107
7	165	159	115	107	58	61	35	28	144	134
8	187	182	120	102	59	60	40	29	88	82
9	217	208	129	115	53	57	31	23	178	164
10	151	146	98	93	46	52	41	30	240	226
11	161	155	114	99	45	52	36	27	199	184
12	180	173	99	94	46	56	45	32	137	127
13	158	153	118	99	58	63	38	29	190	176
14	173	167	86	74	51	57	27	23	116	110
15	211	203	116	104	45	54	35	31	144	131
16	153	140	123	102	57	60	22	20	90	82
17	194	182	115	101	50	55	37	29	155	140
18	206	187	96	92	51	57	48	30	106	101
19	186	175	100	94	52	59	40	32	183	127
20	157	151	126	120	43	49	36	28	172	146
21	203	192	158	144	46	53	56	49	180	172
22	197	189	103	95	48	55	28	25	280	254
23	210	197	109	98	50	54	26	25	62	110
24	185	173	119	107	55	59	41	33	199	132
25	196	185	131	122	50	52	24	20	108	97
26	212	200	129	117	51	58	46	33	224	206
27	176	165	115	96	53	59	36	27	104	96
28	195	187	129	115	57	62	40	33	163	158
29	207	199	100	91	46	57	34	29	121	112
30	209	198	118	110	48	56	53	38	179	139

Table 5: Controlled Group

Table 6: Experimental Group

S.No	Cholesterol Mg/dl		LDL Mg/dl		HDL Mg/dl		VLDL Mg/dl		Triglycerides Mg/dl	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	173	165	120	99	45	52	36	30	170	159
2	202	188	88	82	42	47	35	28	158	142
3	185	178	105	93	33	42	39	31	156	143
4	154	148	104	99	45	53	29	24	144	137
5	189	176	139	98	40	45	26	22	178	162
6	215	179	120	96	37	40	24	20	127	117
7	145	132	115	98	38	40	32	25	174	165
8	187	174	123	99	39	43	40	29	182	178
9	207	191	131	95	43	47	31	23	172	158
10	141	141	98	83	36	42	28	23	238	226
11	167	159	114	92	45	52	36	28	197	184
12	190	180	99	91	36	46	45	32	147	137
13	148	143	129	99	38	43	38	29	190	174
14	183	177	86	74	51	57	27	23	116	109
15	201	190	117	99	45	54	27	22	144	131
16	143	140	123	91	37	40	22	22	165	158
17	192	182	115	99	50	55	36	28	157	142
18	200	187	76	94	40	47	48	32	106	100
19	176	169	100	84	32	40	40	34	183	175
20	154	150	126	98	33	41	32	27	172	164
21	201	190	158	93	36	38	56	50	180	172
22	199	189	112	95	38	45	20	27	280	254
23	210	195	119	96	40	44	20	30	92	80
24	181	173	109	97	45	47	41	33	199	182
25	194	185	131	99	40	42	24	20	108	97
26	220	209	119	97	41	46	46	35	224	206
27	186	175	115	96	51	58	36	26	104	96
28	195	187	124	98	37	42	40	33	163	158
29	204	199	100	85	36	47	32	28	121	112
30	206	200	118	89	38	46	53	41	179	159

Probiotics dramatically lowered cholesterol levels, as seen by a more pronounced decrease in total cholesterol in the experimental group. The significant decrease in LDL levels in the experimental group and the smaller change in LDL levels in the control group suggest that probiotics may have a more significant impact on decreasing LDL cholesterol than the intervention administered to the control group. Both the experimental and control groups' lipid profiles were improved by higher HDL levels. As HDL increased more consistently among the participants, probiotics might be a better strategy for increasing "good" cholesterol. Reduced triglyceride levels were partially due to a decrease in VLDL levels. The slightly more pronounced reduction in VLDL implies that probiotics may be more beneficial in decreasing lipoproteins rich in triglycerides in the experimental stage. A drop in triglycerides indicates better lipid metabolism. The experimental group's triglycerides dramatically dropped, indicating that probiotics might be a more useful strategy for regulating triglyceride levels.

		Experimental				Controlled			
S.No	**Lipid profile**	**Mean mg/dl**		**S.D Mg/dl**		**Mean mg/dl**		**S.D Mg/dl**	
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
	Cholesterol	184.93	175.03	22.51	19.76	186.87	178.03	19.76	18.44
	LDL	114.43	93.60	16.51	6.33	115.00	103.67	15.64	13.46
	HDL	40.23	46.03	5.08	5.44	50.90	56.37	4.48	3.48
	VLDL	34.63	28.50	9.26	6.36	37.33	29.47	7.81	5.37
	Glycerides	164.20	152.57	41.19	38.65	153.27	139.10	48.87	41.49

Table 7: Lipid Profile

Because probiotics increase HDL cholesterol, decrease LDL cholesterol, and drop triglycerides, they may dramatically improve lipid profiles in diabetic patients. In addition, probiotics can regulate lipids, alter gut flora, lower systemic inflammation, and regulate glucose levels. When taken as a whole, these advantages give people with diabetes improved general health and a lower chance of cardiovascular issues. The data displays the lipid profiles of the two groups, the Experimental and the Controlled. Lipid profile measurements, such as cholesterol, LDL, HDL, VLDL, and triglycerides, were evaluated for each group before (Pre) and after (Post) a probiotic treatment. The HDL levels in the experimental group increased, indicating that probiotics helped to increase "good" cholesterol. A decrease in VLDL levels could indicate a reduction in the body's triglyceride levels, usually associated with a lower risk of cardiovascular disease.

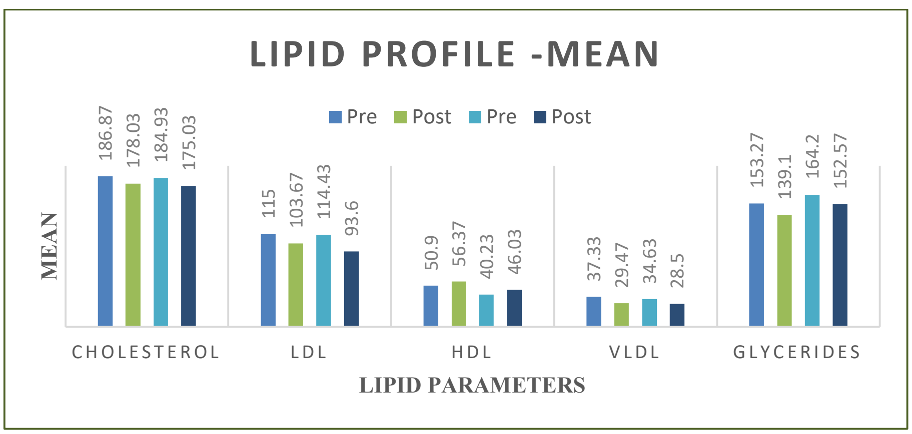

Fig 6: Lipid Profile -Mean

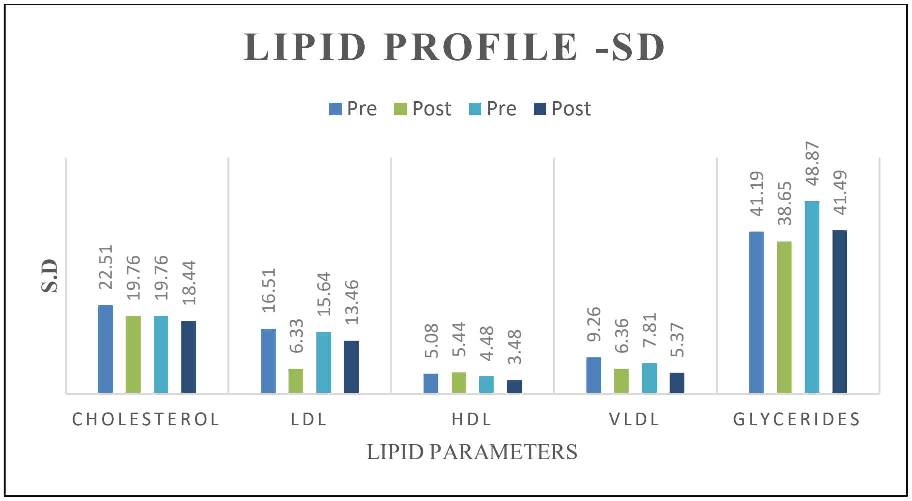

Fig 7: Lipid Profile -S.D.

Lipid Profile	Mean Difference		SD Difference		T value		P-value	
	Cntrl	Expmntl	Cntrl	Expmntl	**Cntrl**	**Expmntl**	**Cntrl**	**Expmntl**
Cholesterol	8.84	9.90	19.76	22.51	2.45	2.41	0.021	0.023
LDL	11.33	20.83	15.64	16.51	3.96	6.92	0.0004	<0.0001
HDL	5.47	5.80	4.48	5.08	6.67	6.24	<0.0001	<0.0001
VLDL	7.86	6.13	7.81	9.26	5.49	3.63	<0.0001	0.0011
Glycerides	14.17	11.63	48.87	41.19	1.59	1.55	0.12	0.13

Table 8: Lipid Parameters (Mean Difference and T Value)

The T value, a ratio, compares the differences between two group averages divided by the group variability. A more considerable T value indicates a more significant difference between the groups compared to variation. In this table, higher T values indicate a more consistent and meaningful change in the lipid profile parameters between pre-and post-treatment. The P value indicates the probability that the observed findings are the product of random chance rather than a real impact. Lower P values (< 0.05) imply a statistically significant outcome, suggesting strong evidence to reject the null hypothesis (no change) and deduce that the treatment had an effect.

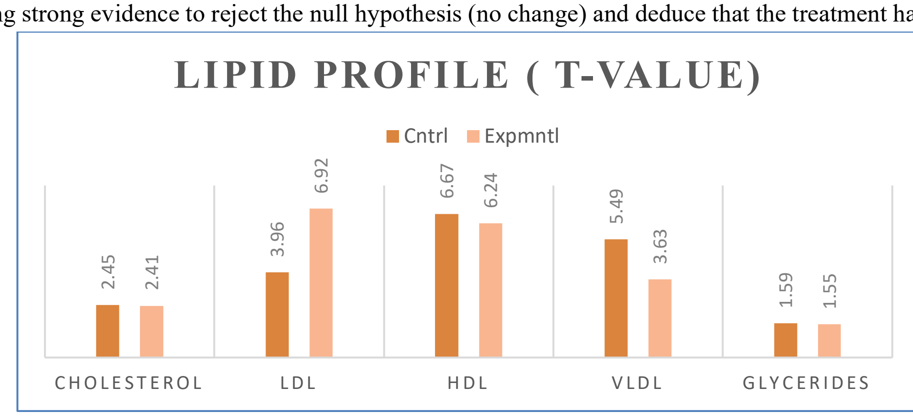

Fig 8: Lipid Profile (T-Value)

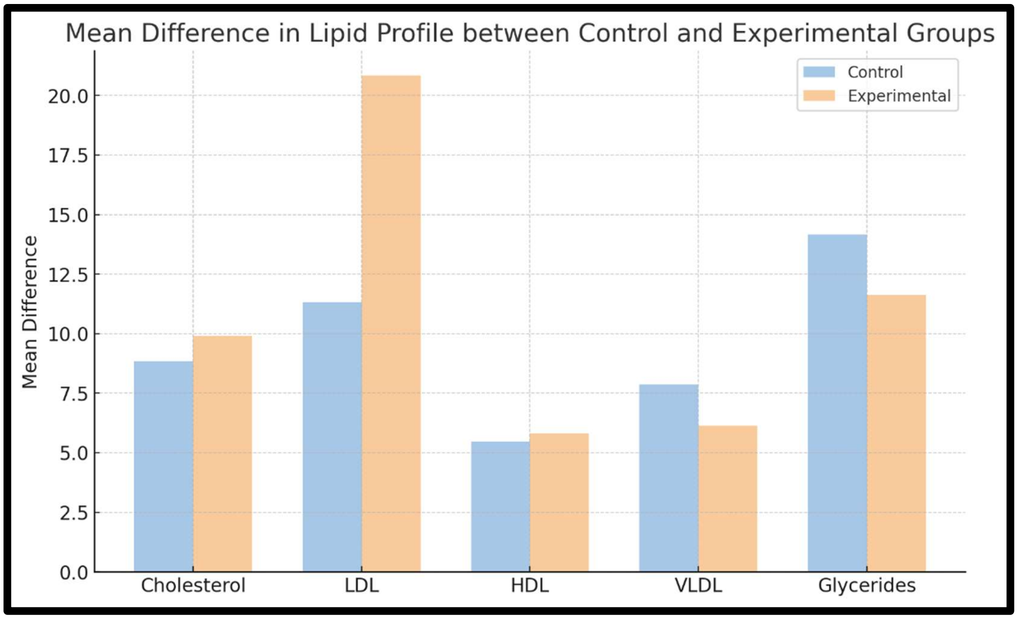

Fig 9: Mean Difference

The graph displays the average difference between the experimental and control groups' lipid profile metrics. The mean differences between the lipid metrics—triglycerides, cholesterol, LDL, HDL, and VLDL—are shown on the graph. The LDL parameter shows a significant difference between the two groups, with the experimental group's mean difference being much more significant than the control group's. There is minimal variation in HDL between the two groups. Triglycerides and cholesterol reveal a slight change in mean differences between the Control and Experimental groups, with the former exhibiting a significant difference.

S.No	Serum Bilirubin (mg/dl) (0.2 -1.2)		Serum Alkaline Phosphatase (44 – 150 I.U. units)		SGPT (I.U) (0-45 U/L)	
	Pre	Post	Pre	Post	Pre	Post
1	1.5	1.3	165	150	50	47
2	1.9	1.5	158	149	48	45
3	2.1	1.5	159	148	47	45
4	2.0	1.6	156	150	51	48
5	1.8	1.4	155	151	50	42
6	1.8	1.2	158	151	55	46
7	1.9	1.3	159	150	49	47
8	1.7	1.2	158	152	51	48
9	1.8	1.1	157	149	52	48
10	1.5	1.2	168	149	48	45
11	2.1	1.6	167	155	47	45
12	1.9	1.3	162	148	49	48
13	2.5	1.8	175	156	50	44
14	2.3	1.7	170	154	55	49
15	1.9	1.3	165	152	56	48
16	1.8	1.2	163	150	55	47
17	2.0	1.4	164	157	49	47
18	2.3	1.8	159	145	49	45
19	1.8	1.2	163	151	54	44
20	1.9	1.1	158	140	55	45
21	1.7	0.9	155	150	50	45
22	2.3	1.6	151	145	48	43
23	2.4	1.4	152	148	47	43
24	2.5	1.5	155	150	49	45
25	1.8	1.2	167	151	50	46

26	1.9	1.4	156	147	52	47
27	1.4	1.4	169	152	49	45
28	1.8	1.5	170	154	51	46
29	1.7	1.3	175	156	53	48
30	1.8	1.2	171	150	54	48

Table 9: Liver Functioning Test

The standard deviation quantifies the degree of variance or dispersion in a collection of values within a controlled group. From the pre- to post-intervention period, the standard deviation for serum bilirubin decreased, indicating that the intervention increased the consistency of the measurements. Serum alkaline phosphatase's S.D. also decreased, suggesting less fluctuation following the intervention. Similar decreases in the SGPT's S.D. imply that post-intervention values were more in line with the mean. A lower standard deviation after the intervention shows that the treatment stabilized liver function parameters, which improved participant consistency in the measurements.

Readings	Serum Bilirubin		Serum Alkaline Phosphatase		SGPT	
	Pre	Post	Pre	Post	Pre	Post
Mean	1.97	1.37	161.43	150.13	50.13	45.27
Standard Deviation	0.30	0.22	6.82	3.74	2.77	1.82
Standard Error	0.05	0.04	1.25	0.68	0.51	0.33

Table 10: LFT (Mean Values & S.D)

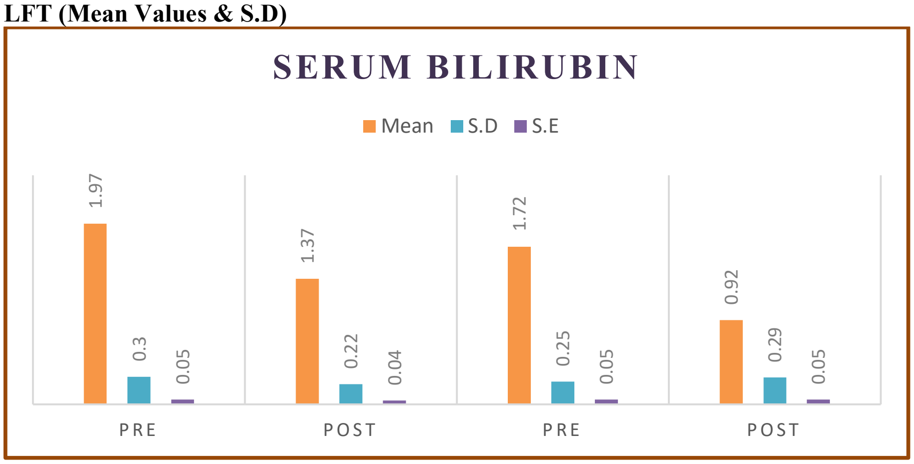

Fig 10: Serum Bilirubin- Controlled

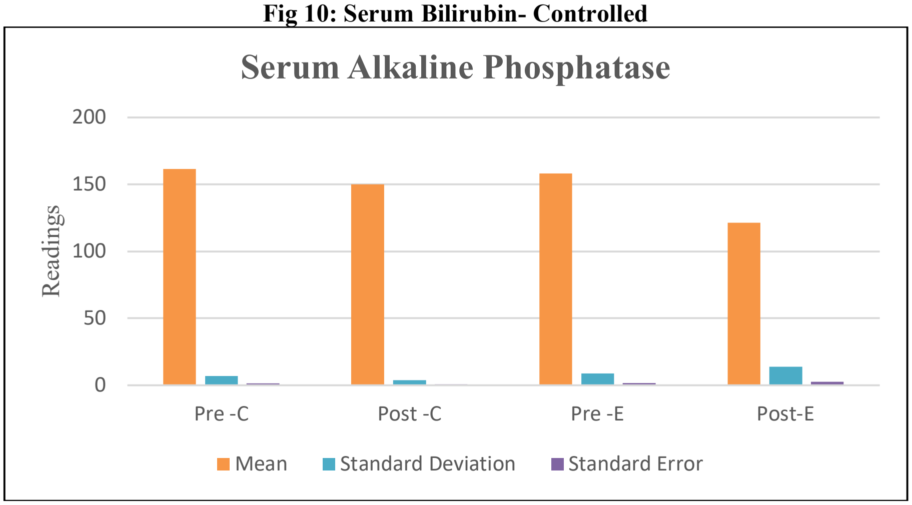

Fig 11: Serum Alkaline Phosphatase

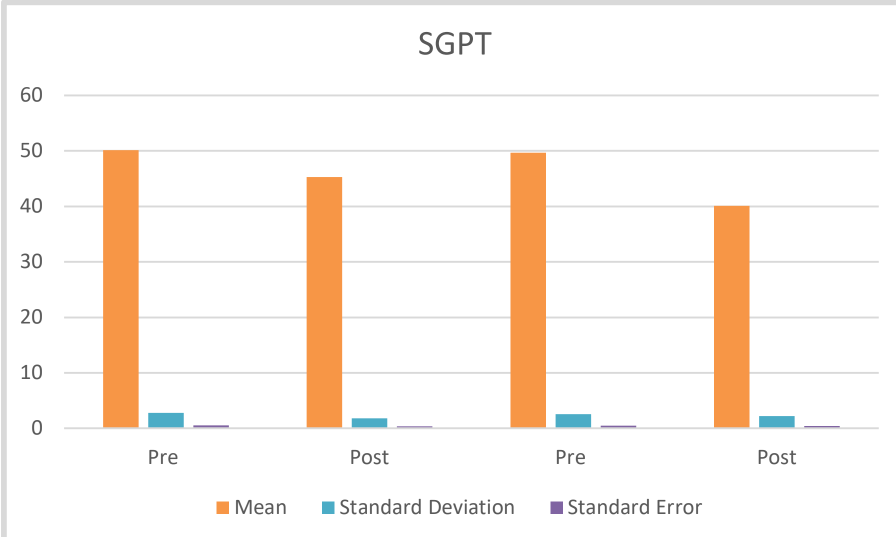

Fig 12: SGPT

After the intervention, the mean blood bilirubin level in the experimental group significantly decreased, falling from 1.72 mg/dl to 0.92 mg/dl. A slight increase in the standard deviation signifies a marginal rise in the variability of the subjects. However, the standard error remained constant, indicating that the mean estimations were consistently accurate. The mean serum alkaline phosphatase level dropped dramatically following the treatment, from 158.13 I.U. to 121.30 I.U. The mean SGPT level dramatically decreased after the intervention, going from 49.70 I.U. to 40.10 I.U. The post-intervention mean estimate shows a lowering standard deviation and standard error, suggesting more precision and less variability.

S.No	Serum Bilirubin (mg/dl) (0.2 -1.2)		Serum Alkaline Phosphatase (44 – 150 I.U. units)		SGPT (I.U) (0-45 U/L)	
	Pre	Post	Pre	Post	Pre	Post
1	1.5	0.9	160	125	50	42
2	1.8	1.0	155	130	48	40
3	2.0	1.2	159	117	47	38
4	2.2	1.3	151	129	49	41
5	1.9	1.2	154	110	46	39
6	1.7	0.9	152	112	45	40
7	1.6	0.8	159	120	48	42
8	1.9	1.0	158	95	51	43
9	1.8	1.1	153	107	52	43
10	1.4	0.6	168	119	46	44
11	1.9	1.2	156	128	48	41
12	1.7	0.9	147	105	47	39
13	1.5	0.8	175	86	51	41
14	1.3	0.5	170	107	52	41
15	1.6	0.6	165	128	53	42
16	1.9	1.1	153	112	55	43
17	2.0	1.2	154	135	49	36
18	2.1	1.2	159	132	48	37
19	1.8	1.0	163	141	52	40
20	1.5	0.9	158	149	53	40
21	1.4	0.7	145	125	47	44
22	1.3	0.6	141	118	46	41
23	2.1	1.2	152	135	48	39
24	2.2	1.2	145	122	49	38
25	1.6	0.3	147	116	52	40
26	1.4	0.4	146	118	51	41
27	1.3	0.4	149	120	49	37

28	1.8	0.5	170	128	50	36
29	1.8	0.6	175	136	53	40
30	1.7	0.6	171	140	50	41

Table 11: LFT – Experimental Group

Readings	Serum Bilirubin		Serum Alkaline Phosphatase		SGPT	
	Pre	Post	Pre	Post	Pre	Post
Mean	1.72	0.92	158.13	121.30	49.70	40.10
Standard Deviation	0.25	0.29	8.82	13.98	2.58	2.21
Standard Error	0.05	0.05	1.61	2.55	0.47	0.40

Table 12: LFT – Experimental Group

According to the research, the probiotics considerably lowered the levels of serum bilirubin, alkaline phosphatase, and SGPT. The reduction in certain liver function test results suggests that the intervention may have improved liver health. The differences in standard errors and standard deviations provide additional context:

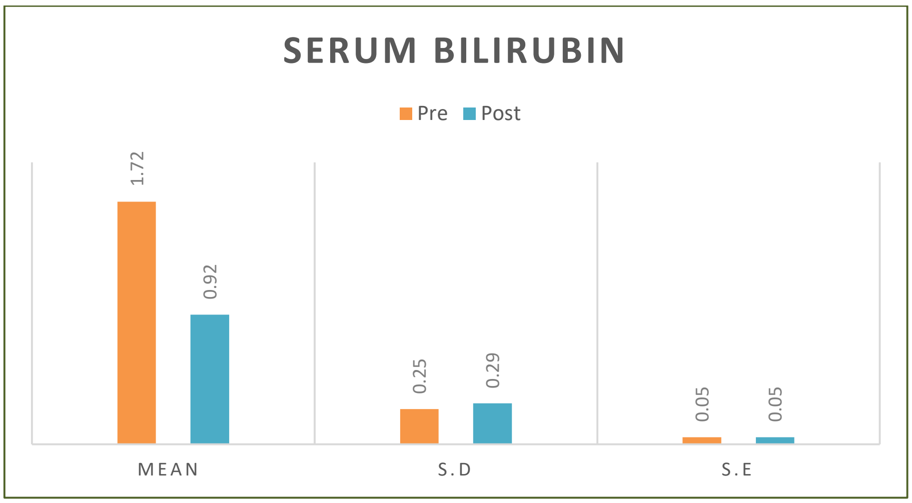

Fig 13: Serum Bilirubin – Experimental

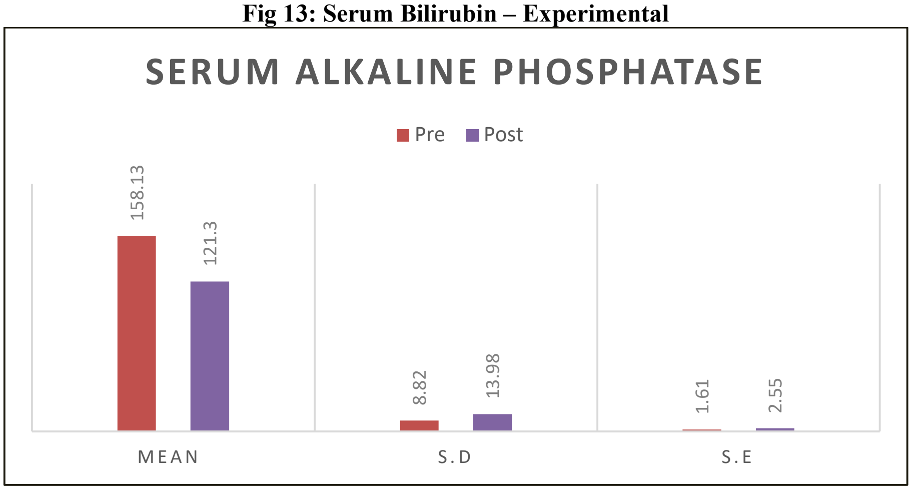

Fig 14: Serum Alkaline Phosphatase

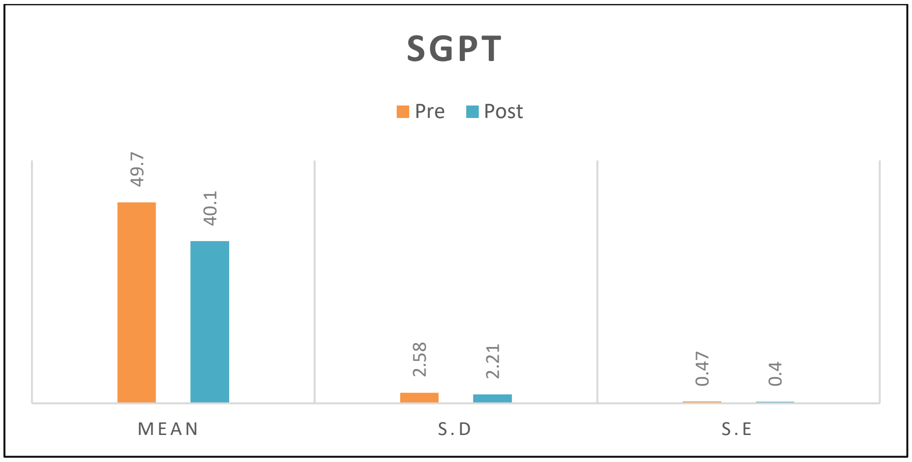

Fig 15: SGPT

Group/ Variables	Controlled Group			Experimental Group		
	S.B	S.A.P	SGPT	S.B	S.A.P	SGPT
Mean difference	0.60	11.30	4.86	0.80	36.83	9.60
Standard Error	0.045	1.05	0.48	0.050	2.16	0.49
T-Value	13.33	10.76	10.13	16.00	17.05	19.59

Table 13: Mean Difference (LFT)

Serum bilirubin (t = 13.33), serum alkaline phosphatase (t = 10.76), and SGPT (t = 10.13) are the three t-values for the serum variables in the Controlled Group that are relatively substantial and demonstrate significant differences between pre-and post-test levels. Similar to this, the t-values for the serum alkaline phosphatase, serum bilirubin, and SGPT in the experimental group (t = 17.05, t = 16.00, and t = 19.59, respectively) are all large, showing a significant change in the variables from the pre-test to the post-test. Serum bilirubin, serum alkaline phosphatase, and SGPT in both the Controlled and Experimental Groups showed statistically significant differences between pre-and post-test levels, according to the results of the paired sample t-test. This suggests that the use of probiotics noticeably affected the biochemical parameters of these groups.

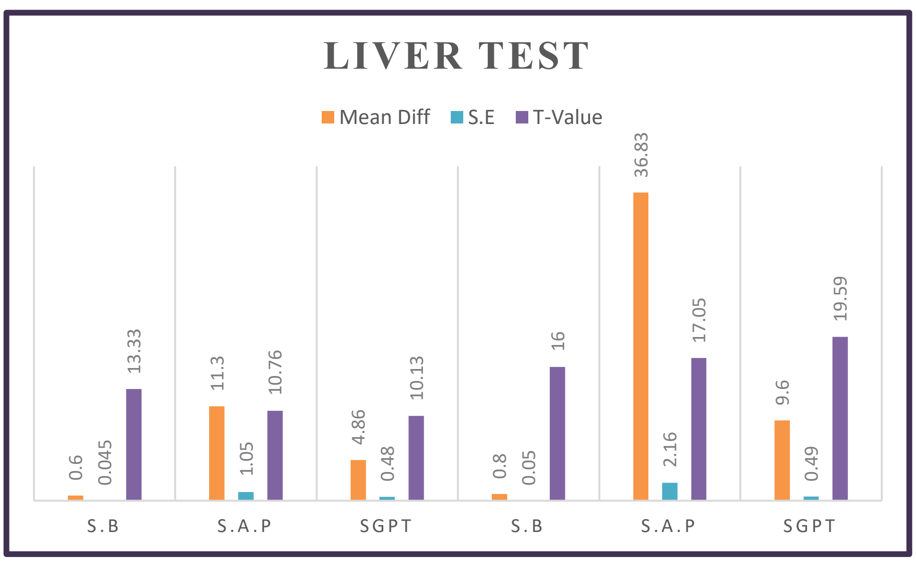

Fig 16: Mean Difference (LFT)

Elevated levels of bilirubin could suggest obstruction of the bile duct or issues related to the liver. After taking probiotics, the Experimental Group's bilirubin levels decreased, suggesting improved liver function. Improved

SAP readings are associated with bone issues, liver disease, and bile duct obstruction. Probiotic use was associated with decreased SAP levels (seen in both groups), which could indicate a positive impact on liver function. High SGPT levels suggest liver damage or inflammation (Lala et al., 2023). As was shown in both groups, SGPT levels dropped after probiotic use, which would point to lessened liver injury or inflammation.

Conclusion

Probiotics could be a beneficial dietary intervention for glycemic management since this benefit is particularly noteworthy for people who are at risk of developing type 2 diabetes or who currently have the disease. The data demonstrates that the experimental and control groups significantly changed over the 90 days. Particularly in the experimental group, there is a discernible rise in the mean differences between the pre-supplementation phase and the ensuing time points (30, 60, and 90 days). After 30 days, the experimental group showed a more significant mean difference (30.20) than the control group (6.53), according to the paired t-test result of 38.48, which indicates a significant difference between the groups. The experimental group's mean difference for 90 days is 62.97, more than twice as large as the control group's mean difference of 23.93. A paired t-test value of 56.08 indicates a highly significant difference, which shows the supplementation's steady effect over time. The experimental group's increasing trend compared to the control group suggests that the supplementation had a noteworthy and advantageous impact. Fermented tea with probiotics has the potential to increase HDL (good) cholesterol while lowering LDL (bad), total, and triglyceride levels (Momin et al., 2023;Rasool et al., 2020 and 2022).

As stated by Rizvi et al. (2024), probiotics have been proven to enhance insulin synthesis, modify gut microbiota composition, and control metabolites such as butyrate and acetate. These effects have all demonstrated potential in managing blood glucose levels in individuals with diabetes. Additionally, it makes these advantageous changes in lipid profiles possible. Fermented tea with probiotics can increase HDL (good) cholesterol while lowering LDL (bad), total, and triglyceride levels. It also makes these advantageous changes in lipid profiles possible. Probiotics are essential for heart health since these changes are associated with a decreased risk of heart-related diseases (Wu & Chiou, 2021).

Serum bilirubin, serum alkaline phosphatase, and serum SGPT Cohen's d values all demonstrate a significant and noteworthy change in liver enzyme levels after taking probiotics. Based on the considerable effect sizes, fermented tea is a helpful intervention for reducing liver enzyme levels and enhancing liver health (Musazadeh et al., 2022). As demonstrated by lower levels of liver enzymes like SGPT and serum bilirubin, fermented tea is beneficial to liver function. This suggests that probiotics may protect the liver from damage and improve liver function, especially when non-alcoholic fatty liver disease (NAFLD) and other metabolic diseases are present (Cheng et al., 2023). The findings show the potential of kombucha tea as an all-natural, broad-spectrum medicinal agent with specific advantages for liver function, antioxidant defence, metabolic health, and cancer prevention. To completely comprehend these effects and confirm the long-term benefits of consuming probiotic tea made from Kombucha tea on lipid metabolism, more research is necessary.

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