A study of date palm sugar on metabolic disorders in experimental diabetic rats

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Diabetes is a metabolic disease with multifactorial and diverse causes. Humans have two forms of diabetes: type 1 diabetes, which happens when the immune system attacks and eliminates insulin, and type 2 diabetes, which can be triggered by a variety of factors, the most important is a lifestyle, but can also be ascertained by various genotypes. Date palm sugar (DPS) is a good nutritive sugar having good potential in diabetic conditions due to the presence of polyphenols that have strong antioxidant properties. In this research work, we compared the effect of DPS on regular sugar in diabetic rats. We assessed various parameters in normal rats, sugar-treated rats, and diabetes-induced rats, including body weight, food intake, water intake, blood glucose level, insulin level, insulin resistance, lipid profile, atherogenic index, adiponectin, resistin, and TNF alpha. The study says that the usage of DPS produce significant improvement on diabetic rats. However, the DPS is a beneficial substitute than other sugars.

Keywords: Diabetes, date palm sugar, streptozotocin (STZ), nicotinamide (NA)

Diabetes is a significant threat to global public health that is quickly worsening, with the largest influence on working-age adults in developing nations. Diabetes affects at least 177 million individuals globally, and this figure is expected to nearly double by 2030, reaching 366 million[1]. There are two major types of diabetes, with type 2 being more common in adults of varying ages and constantly burgeoning in adolescents and young children. According to recent literature, type 2 diabetes is currently increasing among children worldwide, and it seems to have risen significantly in the last 15 years [2]. Moreover, up to 45% of newly diagnosed cases of diabetes among adolescents are type 2. Type 2 diabetes accounts for 70% of new cases among Native Americans and 80% of new cases of pediatric diabetes in Japan [3, 4]. According to an epidemiological study, the number of diabetic patients is significantly rising in the Asia-

Pacific region [5]. In addition, type 2 diabetes affects 3% of the population in Europe, and its administrative costs account for 5% of all healthcare spending [6]. However, a heterogeneous disorder known as type 2 diabetes is characterized by a gradual loss of insulin action (insulin resistance), which is followed by an inability of β-cells to compensate for the lack of insulin action [7].

Date palm fruits have been discovered to have tremendous potential in the treatment of diabetes due to the presence of polyphenols, which have high antioxidant characteristics. DPS engages in similar activities. Another potential mode of action involves the inhibition of enzymes like glucosidase and amylase by the polyphenolic compound. DPS also contains flavonoids that can increase the number of islets and β-cells, restore endocrine pancreatic tissues, reduce β-cell apoptosis, activate insulin receptors after an increase in insulin secretion, and improve complications associated with diabetes [8–12].

Animal models are frequently used in diabetes research, with rats being the most common choice. Due to their accessibility and affordability, nongenetic rat models are also frequently used in diabetes research in addition to genetic models. Chemical inducers like streptozotocin (STZ) are used to cause diabetes in animals, and a nicotinamide (NA)-STZ model for type 2 diabetes has also been established [13]. In experimental animal models, the quantity and diet of inducers have a significant impact on how diabetes develops. Lower doses of the inducer are ineffectual at inducing diabetes, while higher doses cause severe β-cell damage [14, 15].

Material and method

Experimental Material

The formulation of DPS is purchased from the local market. Which is produced by Ekgaon one village one world network, Tamilnadu. The powder is dissolved in water as a solvent and used for experimental purposes. The composition of the selected DPS is presented in Table 1.

Table 1. Composition of selected Date palm sugar in 100 gm

Composition	Value (%)
Total Fat	
Saturated Fat	0%
Trans Fat	
Cholesterol	0%
Sodium	0%
Potassium	0%
Total Carbohydrate	
Dietary Fiber	32%
Sugar	
Protein	0%
Vitamin C	13.33%
Iron	56.7%

Experimental Animal

Albino SD male rats of the same age group and body weight of 250gm were selected for all the experiments. The number of rats was 120 with the age of 2 months. Rats obtained from the National Institute of Communicable Disease (NICD) New Delhi, India, were housed in polypropylene cages at an ambient temperature of 25-30º C and relative humidity of 45-55% with a 12h each of dark and light cycle. Rats were given pelleted food and water ad libitum.

Ethics

The Ethics Committee approval for the study was obtained by IAEC of Parul University with id PIPH 08/20.

Induction of Diabetes

Diabetes was induced by a single intraperitoneal injection of freshly prepared nicotinamide (230 mg/kg) in saline (10 mg/100 ml) to the group of male rats. After 15 min, freshly prepared Streptozotocin (STZ) (40 mg/kg) in 0.1 M citrate buffer (pH 4.5) was administered to a group of rats that had been fasted overnight. After 72 hours, blood glucose levels were measured in rats.

Experimental work

This study uses in vitro tests on healthy and diabetic rats to assess how various sweeteners affect lipid and carbohydrate metabolism in normal and diabetic people. A major goal of the study on sweeteners is to provide safe alternatives for both healthy and diabetic individuals. Here, Phase I and Phase II studies have been completed. The timeline for the treatment was about 8 weeks. In phase I we have studied the effect of DPS on healthy male rates and measure the response. SD rats aged 2–10 months and weighing 180–250 g were used (Table 2).

However, in the phase II study, we examined the effects of 100–350 mg/kg Nicotinamide (NA) injected intraperitoneally 15 min before intravenous administration of 40 mg/kg STZ in diabetes induced SD male rats. The results suggested NA dosage of 230 mg/kg to be the most appropriate (Table 3).

Table 2. The experimental design as follows

Groups	Name	Treatment and Dose	Duration
Group 1	Normal group	Normal saline (0.2 ml, p.o.)	8 weeks
Group 2	Sugar group	500 mg/kg/day	8 weeks
Group 3	Date palm sugar	500mg/kg/day	8 weeks

The treatment will be continued for 8 weeks, after the following parameters: body weight, food intake, water intake, BGL, insulin level, insulin resistance, lipid profile, atherogenic index, adiponectin, resistin, TNF alpha.

Table 3. Induction nicotinamide and streptozotocin standards

Strain	Fasting state before diabetes induction	Dose of STZ (mg/kg)	Dose of NA (mg/kg)	Time between STZ and NA injection (min)	Time of blood glucose test after diabetes induction/ fasted or non-fasted	Glucose levels (mg/dL) to be considered diabetic
SD	Overnight	40	230	15	72hr	> 250

After induction of type 2 diabetes, the experimental group follows the following experimental design. The treatment will be continued for 8 weeks, after the following parameters (Table 4).

Table 4. Experimental design after induction of type 2 diabetes

Groups	Name	Dose	Duration
Group 2	Sugar + (STZ + NA Induced Type-II Diabetes)	500 mg/kg/day	8 weeks
Group 3	Date palm sugar + (STZ+ NA Induced Type-II Diabetes)	500 mg/kg/day	8 weeks

Moreover, the toxicity study is also carried out for the DPS. Three animals were used for each stage of procedures in which the starting dose was 2000 mg/kg and the upper dose level was fixed at 5000 mg/kg as recommended by sponsor. The given Table 5 shows the detailed information about the animals and their dosage.

Table 5. Number of animal and the dose of DPS

Dose Level of DPS	Animal No.	Body weight on Day (gm)	Dose of DPS (mg)	Dose of DPS (mL)
2000 mg/kg	Head	230	460	0.92
	Body	240	480	0.96
	Tail	230	460	0.92
	Head	280	560	1.4

Repeat dose 2000 mg/kg	Body	270	540	1.08
	Tail	250	500	1.0

Result and discussion

The result shows the data of phase I, phase II and toxicity. The experiment done on different factors such as Body weight, Food intake, Water intake, BGL, Insulin level, Insulin resistance, Lipid profile, Atherogenic index, Adiponectin, Resistin, TNF-alpha.

Result of Phase I

Phase I studies show the effects of different parameters on saline, sugar, and DPS on normal, disease-free animals. Body weight values were determined at the beginning and at the end of the treatment are presented. Body weight in DPS treated animals was decreased about 12 %. In addition, the food intake of DPS treated animals was also decreased where in sugar treated animals it increased. There was a minor reduction observed in the water intake of DPS treated rats which was increased in saline and sugar treated rats. The BGL level was observed to be reduced in DPS treated rats as compared to other two categories. However, the insulin level, HDL level, and LDL level was increased. The level of TG and TC was decreased in DPS treated rats as compared to saline and sugar treated rats. There is no significant change observed in the atherogenic index. Moreover, the level of adiponectin was increased slightly in DPS treated rats. The level of TNF-α and resistin was amplified in the DPS treated rats (Table 6).

Table 6. Evaluation of Biochemical parameter in phase I

Parameters	Beginning of the study	End of the study

	Saline	Sugar	DPS	Saline	Sugar	DPS
Body weight	305±1.89	301±3.10	319±6.87	339±3.76	395±2.89	281±7.57
Food intake	55±0.48	54±0.71	59±1.54	51±2.09	78±2.18	38±0.68
Water intake	49±1.67	52±1.41	49±1.58	50±0.31	53±0.61	46±1.14
BGL	63±8.85	74±1.61	82±4.99	84±1.54	100±0.61	70±1.09
Insulin level	15.15±0.8	14.95±1.04	12.95±1.15	14±0.88	11±1.61	13±1.16
HDL	85.33±3.06	79.13±1.67	83.5±2.09	85±3.06	57±2.78	87±3.86
LDL	109.50±4.1	127.66±2.46	110.16±2.42	117±4.01	150±3.15	121±5.38
TG	113.50±6.45	125.50±3.72	111.17±3.94	111±6.45	139±5.19	106±2.56
TC	126.33±5.60	168.33±5.41	129.33±6.59	135±5.34	181±3.71	122±4.61
Atherogenic index	0.12±0.04	0.30±0.07	0.09±0.06	0.115 ±0.01	0.3 ±0.013	0.09±0.01
Adiponectin	14.98±1.60	14.7±1.88	12.86±0.96	15±1.34	10±0.55	13±0.96
Resistin	14.42±1.16	15.15±0.85	13.78±1.20	12±0.56	16±1.02	11±0.64
TNF-alpha	1.48±0.23	1.55±0.17	1.33±0.25	1±0.18	2±0.17	1±0.25

Results of Phase II

In the phase II study, the animals were in a diabetic state. The effect is seen with normal saline, sugar and DPS. It was shown that there was a significant change in body weight in diabetic rats. Body weight of rats was decreases. Food impact decreases in diabetic and sugar-treated rats, but increases in DPS. However, water intake rises in all conditions. In saline and sugar-treated rats, BGL levels rise, whereas, in DPS rats, BGL levels fall. Contrary to sugar-treated rats and normal diabetic rats, the level of insulin rises in DPS-treated rats when there is no discernible change in either group. Additionally, the level of HDL and LDL, it is higher in DPS-treated animals. The level of TG and TC levels were reduced in DPS treated animals. The

atherogenic index, resistin and TNF-α shows the significant increment in their levels in DPS treated rats. Whereas, the level of adiponectin was reduced in DPS treated rats (Table 7).

Table. 7 Evaluation of Biochemical parameter of phase II trials

Parameters	Beginning of the study			End of the study		
	Saline	Sugar	DPS	Saline	Sugar	DPS
Body weight	316±11.54	315±9.92	319±6.87	234±11.58	292±9.90	281±7.57
Food intake	55±0.85	54±0.71	58±1.54	33±1.47	25±0.61	65±1.07
Water intake	50±0.98	52±2.34	49±1.57	62±1.08	63±1.35	57±1.70
BGL	346±15.37	306±18.51	342±16.47	513±12.15	540±28.60	273±16.30
Insulin level	15.15±0.8	14.95±1.04	12.95±1.15	16.01±0.38	14.95±0.31	13.42±0.59
HDL	85.33±3.06	79.13±1.67	83.5±2.09	66±2.31	58±2.74	85±3.15
LDL	109.50±4.1	127.66±2.46	110.16±2.42	149±4.3 6	159±5.38	139±3.84
TG	113.50±6.45	125.50±3.72	111.17±3.94	106±8.11	146±6.13	102±5.90
TC	126.33±5.60	168.33±5.41	129.33±6.59	142±4.25	165±5.84	126±4.6 4
Atherogenic index	0.12±0.04	0.30±0.07	0.09±0.06	0.31±0.03	0.40±0.22	0.36±0.0 3
Adiponectin	14.98±1.60	14.7±1.88	12.86±0.96	11.86±0.63	10.2±0.62	10.87±2. 91
Resistin	14.42±1.16	15.15±0.85	13.78±1.20	16.94±0.85	18.72± 0.82	14.72±1. 42
TNF-alpha	1.48±0.23	1.55±0.17	1.33±0.25	1.93±0.16	1.88±0.20	1.52±0.2 0

The below graphs shows the result of phase I and phase II trials on rats.

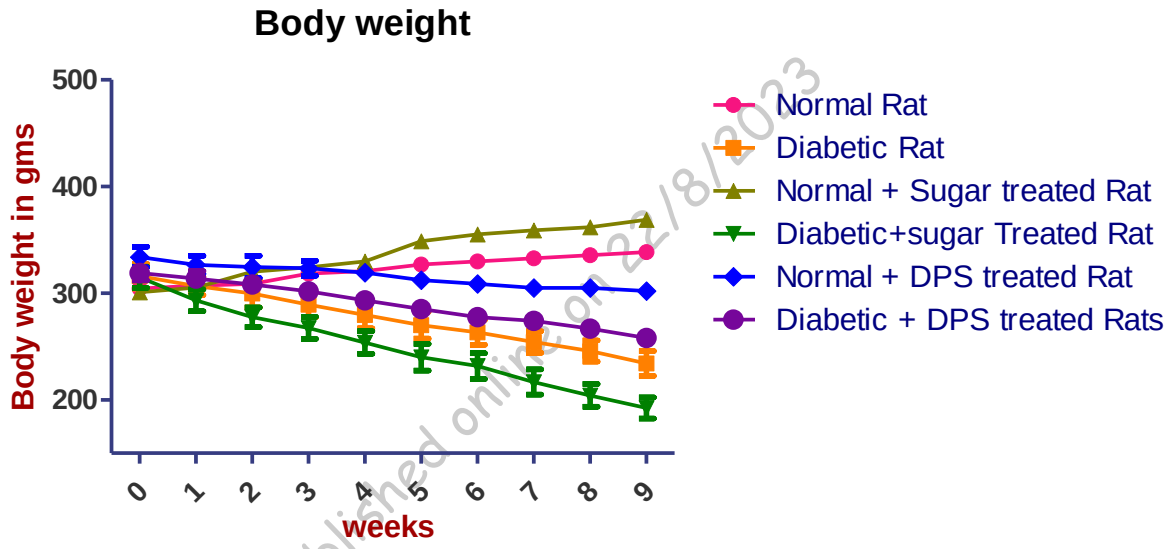

Figure 1. Effect of DPS on body weight

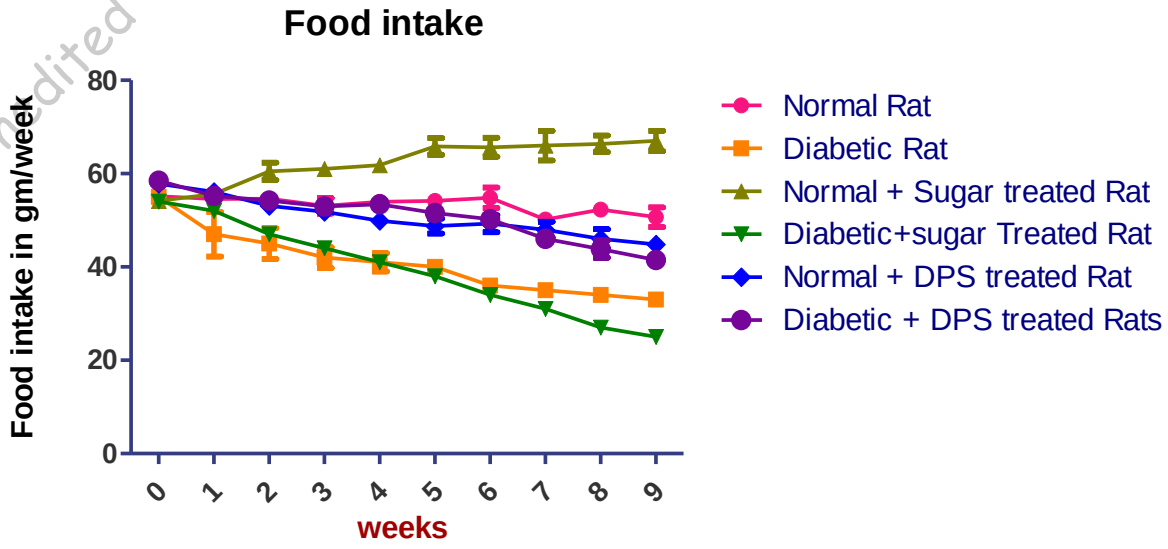

Figure 2. Effect of DPS on food intake

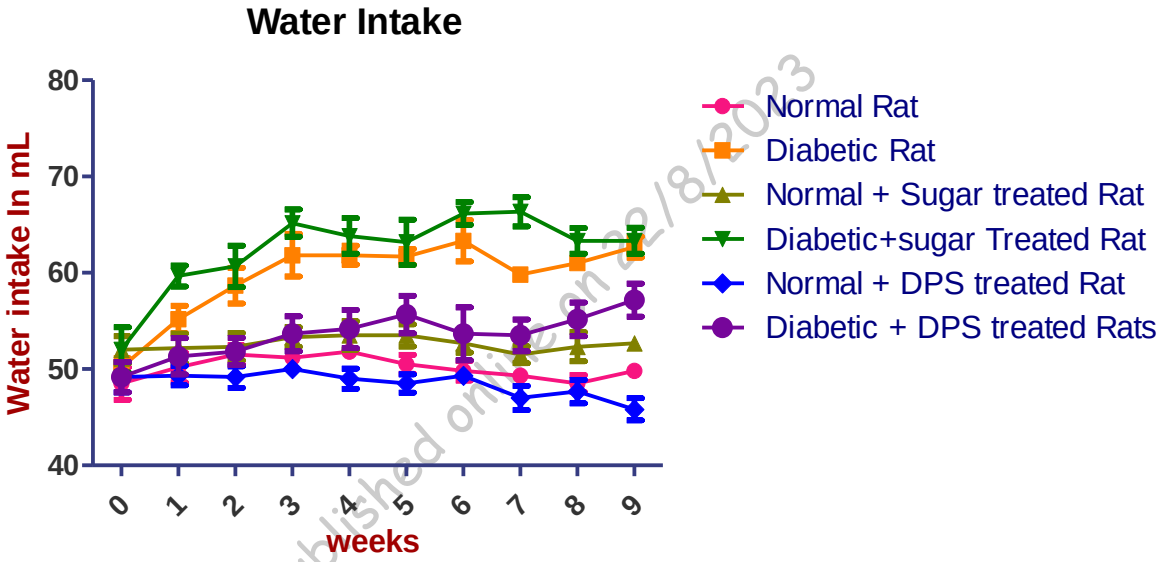

Figure 3. Effect of DPS on water intake

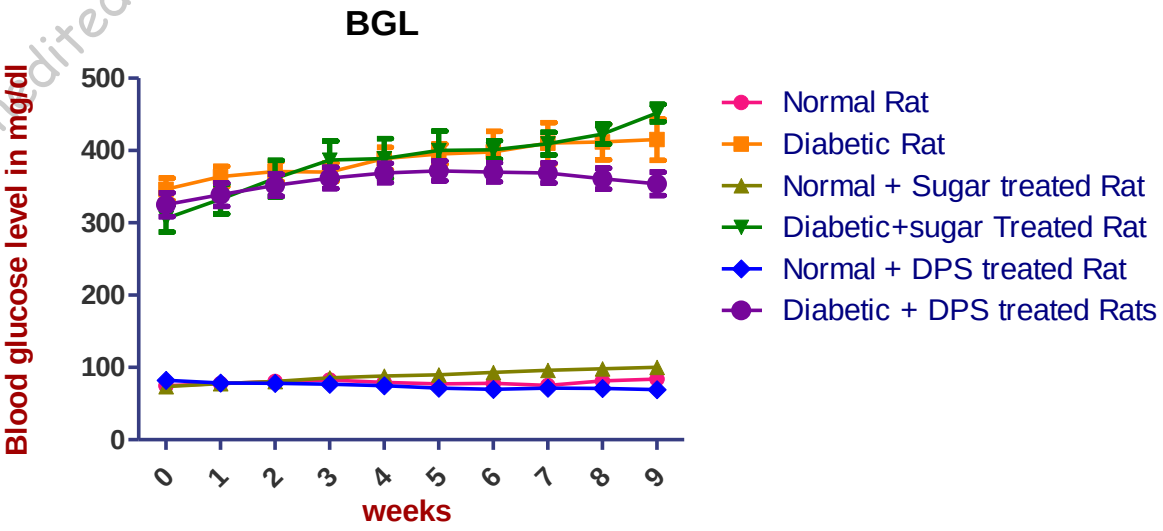

Figure 4. Effect of DPS on blood glucose level

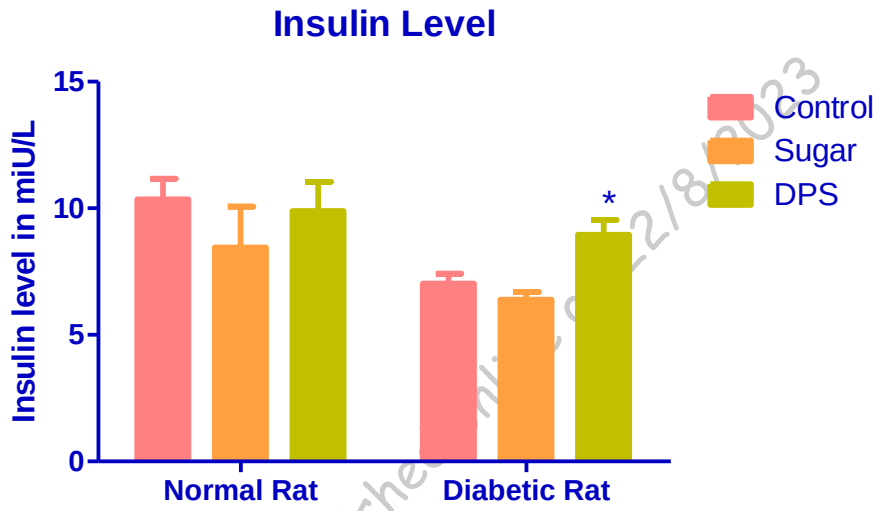

Figure 5. Effect of DPS on insulin level

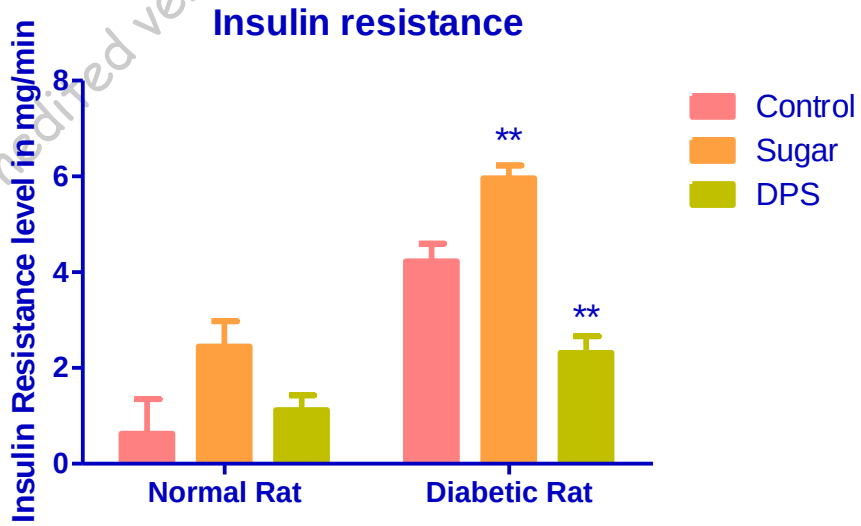

Figure 6. Effect of DPS on insulin resistance

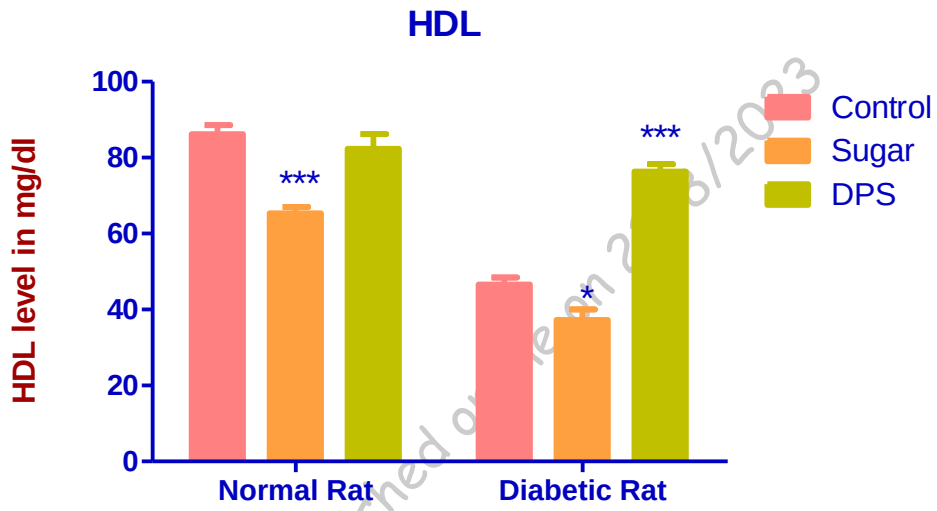

Figure 7. Effect of DPS on HDL level

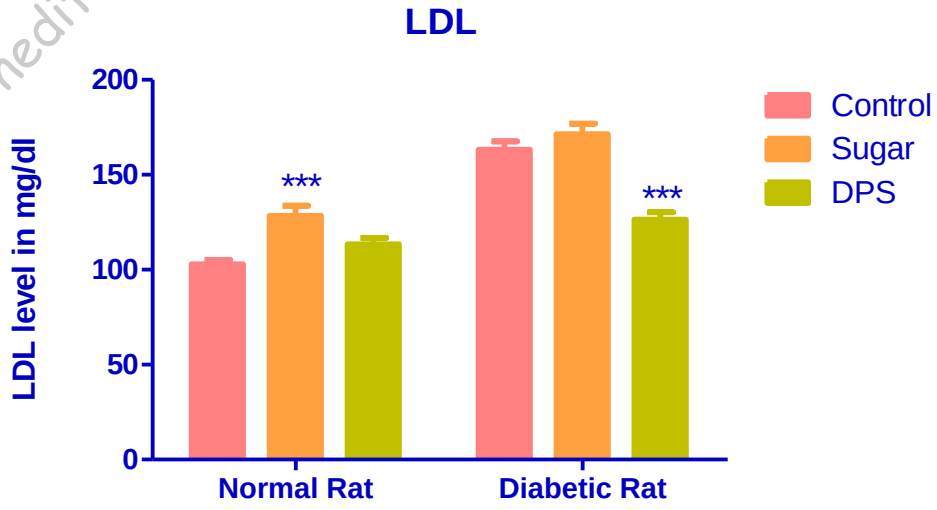

Figure 8. Effect of DPS on LDL level

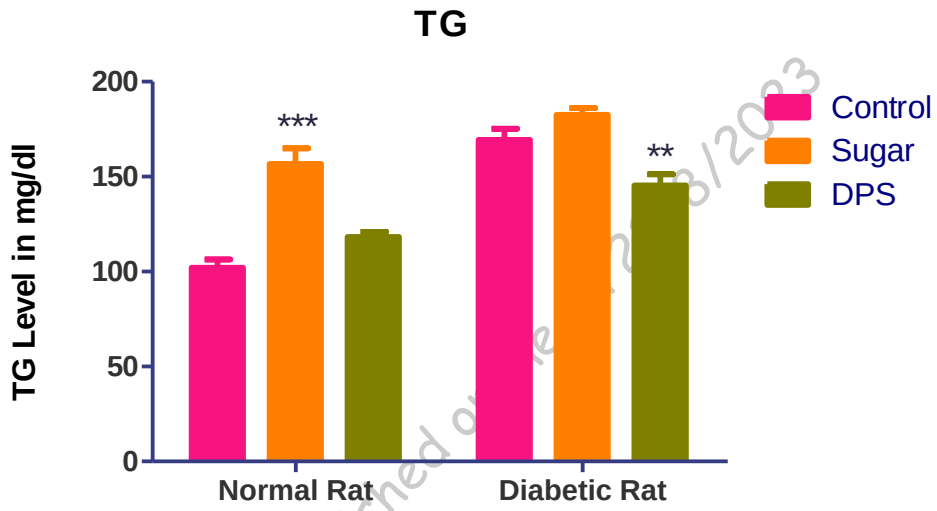

Figure 9. Effect of DPS on TG level

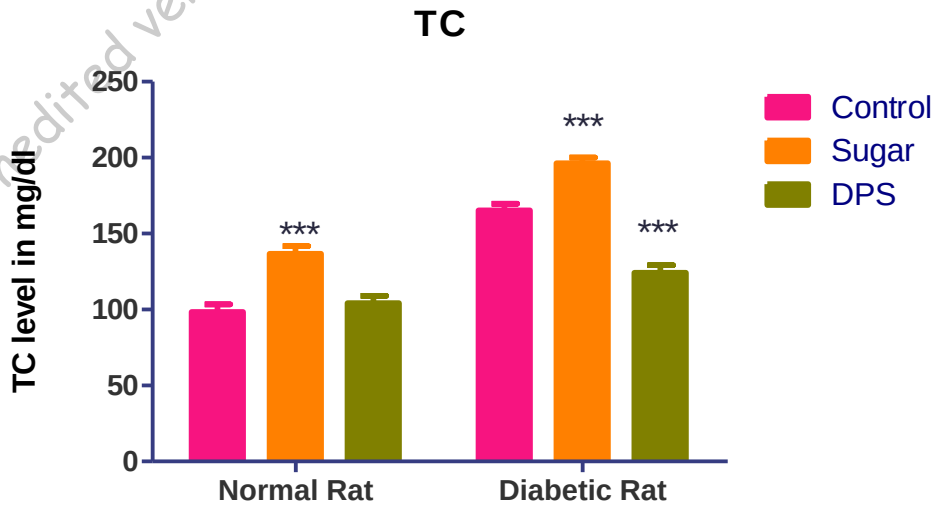

Figure 10. Effect of DPS on TC level

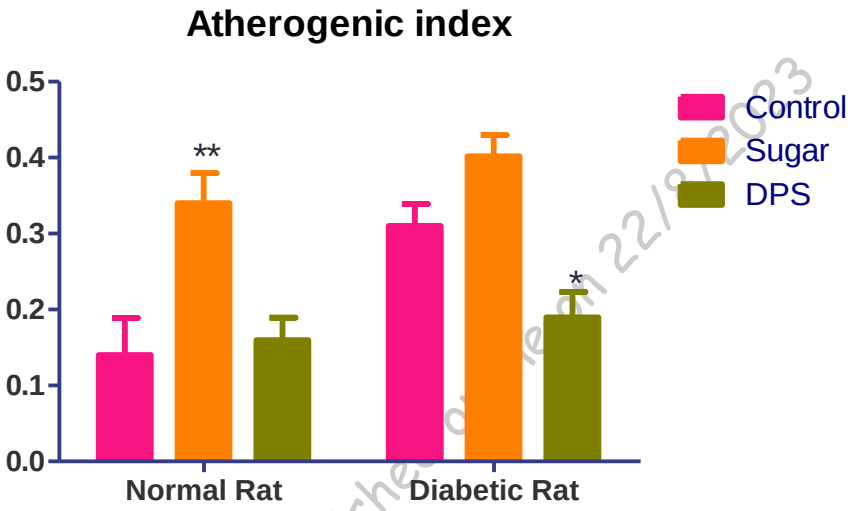

Figure 11. Effect of DPS on atherogenic index

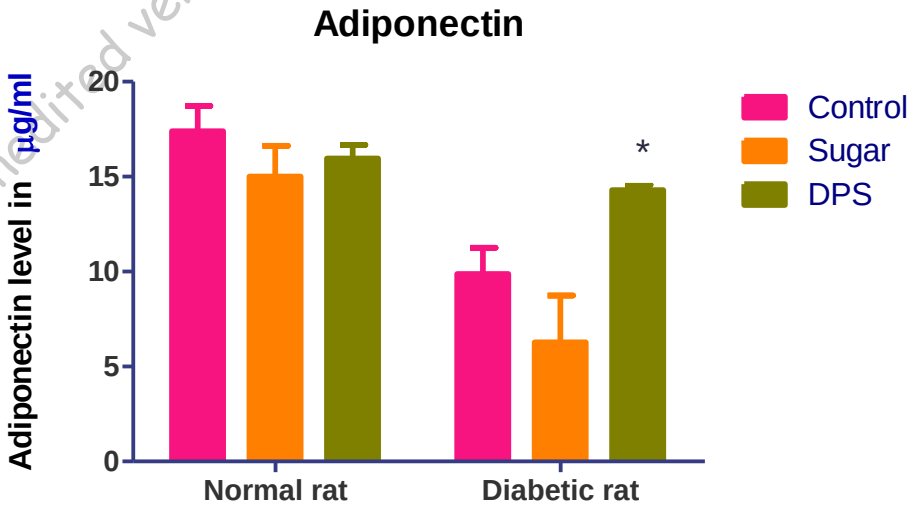

Figure 12. Effect of DPS on adiponectin level

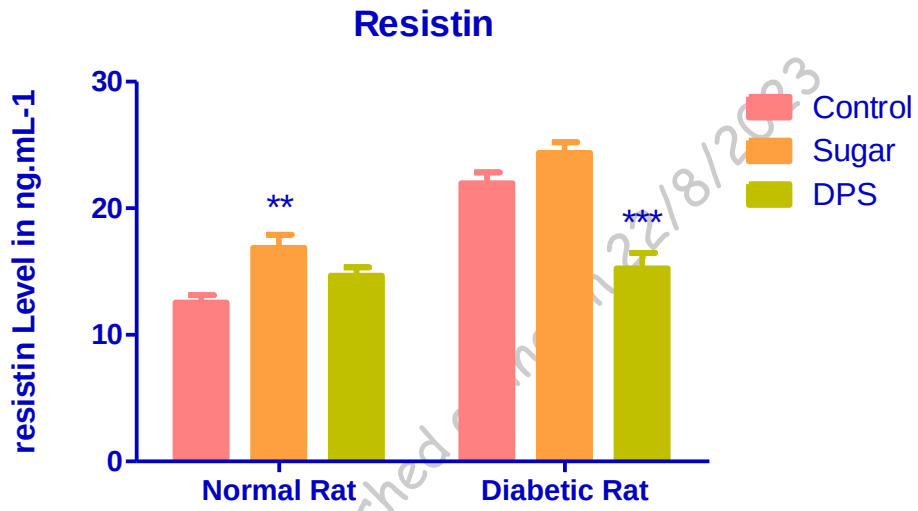

Figure 13. Effect of DPS on resistin level

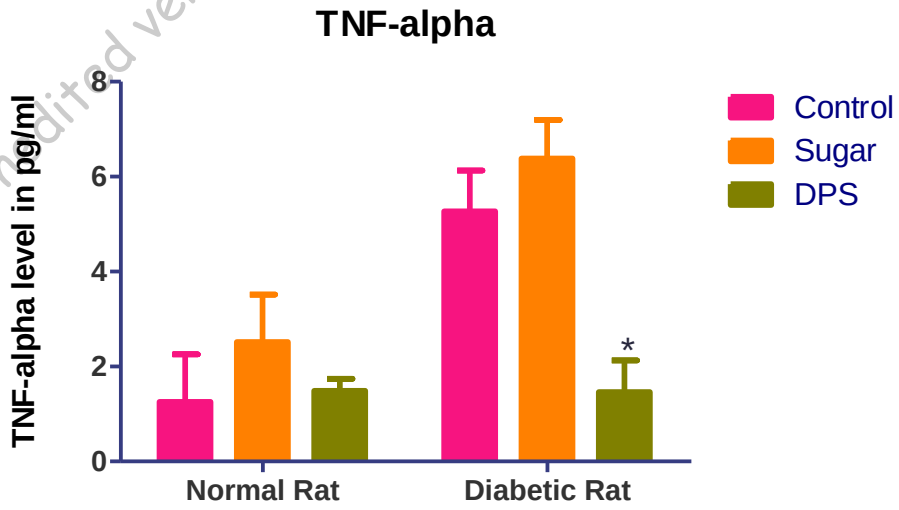

Figure 14. Effect of DPS on TNF-alpha level

Toxicity study

The animal toxicity test is conducted on each animal after dosing for the first 30 minutes, every hour for the following 4 hours, and every 6 hours for the following 24 hours. The animals were observed daily thereafter, for a total of 14 days. It is shown that there is no signs of toxicity or abnormal behavior was observed in any of the animals. Body weight of the test animals were recorded every week for each animal, as reported in the table 8. There were no abnormal

changes observed in body weight. All test animals were subjected to gross necropsy at the end of 14 days. The table indicate individual animal observation at the dose of 2000mg/kg as well as the same repeated dose effects (Table 9).

Table 8. Individual Animal Observations for 14 days

Dose Level	Animal ID	Body weight			Mortality	Signs of toxicity			Gross necropsy
		Day 0 (gm)	Day 7 (gm)	Day 14 (gm)		Nature	Severity	Duration	
2000 mg/kg	Head	230	240	235	No	NAD	NAD	NAD	NAD
	Body	240	240	235	No	NAD	NAD	NAD	NAD
	Tail	230	240	240	No	NAD	NAD	NAD	NAD
Repeat dose 2000 mg/kg	Head	280	280	290	No	NAD	NAD	NAD	NAD
	Body	270	280	275	No	NAD	NAD	NAD	NAD
	Tail	250	250	245	No	NAD	NAD	NAD	NAD

NAD: No abnormality detected

Table 9. Individual Animal Cage Side Observations for dose level 2000 mg/kg

Animal ID	Observation parameters	Observation at Specific time Interval (hr)						
		0	0.5	1	2	3	4	24
Head	Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil

	Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Body	Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Tail	Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Conclusion

We found that the DPS produced significant improvements in diabetic rats. The results of this study demonstrate that 8 week consumption of DPS can provide advantageous effects on body weight, food intake, water intake, BGL, insulin level, insulin resistance, lipid profile, atherogenic index, adiponectin, resistin, TNF alpha in diabetic rats. Thus, it's indicates that the usage of DPS instead of other sugars give beneficiary effect in diabetic individuals.

Conflict of interest: The authors declare no conflict of interest.

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Tables:

Table 1. Composition of selected Date palm sugar in 100 gm

Composition	Value (%)
Total Fat	
Saturated Fat	0%
Trans Fat	
Cholesterol	0%
Sodium	0%
Potassium	0%
Total Carbohydrate	
Dietary Fiber	32%
Sugar	
Protein	0%
Vitamin C	13.33%
Iron	56.7%

Table 2. The experimental design as follows

Groups	Name	Treatment and Dose	Duration
Group 1	Normal group	Normal saline (0.2 ml, p.o.)	8 weeks
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Group 3	Date palm sugar	500mg/kg/day	8 weeks

Table 3. Induction nicotinamide and streptozotocin standards

Strain	Fasting state before diabetes induction	Dose of STZ (mg/kg)	Dose of NA (mg/kg)	Time between STZ and NA injection (min)	Time of blood glucose test after diabetes induction/ fasted or non-fasted	Glucose levels (mg/dL) to be considered diabetic
SD	Overnight	40	230	15	72hr	> 250

Table 4. Experimental design after induction of type 2 diabetes

Groups	Name	Dose	Duration
Group 2	Sugar + (STZ + NA Induced Type-II Diabetes)	500 mg/kg/day	8 weeks
Group 3	Date palm sugar + (STZ+ NA Induced Type-II Diabetes)	500 mg/kg/day	8 weeks

Table 5. Number of animal and the dose of date palm sugar

Dose Level of DPS	Animal No.	Body weight on Day (gm)	Dose of DPS (mg)	Dose of DPS (mL)
2000 mg/kg	Head	230	460	0.92
	Body	240	480	0.96
	Tail	230	460	0.92
Repeat dose 2000 mg/kg	Head	280	560	1.4
	Body	270	540	1.08
	Tail	250	500	1.0

Table 6. Evaluation of Biochemical parameter in phase I

Parameters	Beginning of the study			End of the study		
	Saline	Sugar	DPS	Saline	Sugar	DPS
Body weight	305±1.89	301±3.10	319±6.87	339±3.76	395±2.89	281±7.57
Food intake	55±0.48	54±0.71	59±1.54	51±2.09	78±2.18	38±0.68
Water intake	49±1.67	52±1.41	49±1.58	50±0.31	53±0.61	46±1.14
BGL	63±8.85	74±1.61	82±4.99	84±1.54	100±0.61	70±1.09
Insulin level	15.15±0.8	14.95±1.04	12.95±1.15	14±0.88	11±1.61	13±1.16
HDL	85.33±3.06	79.13±1.67	83.5±2.09	85±3.06	57±2.78	87±3.86
LDL	109.50±4.1	127.66±2.46	110.16±2.42	117±4.01	150±3.15	121±5.38
TG	113.50±6.45	125.50±3.72	111.17±3.94	111±6.45	139±5.19	106±2.56
TC	126.33±5.60	168.33±5.41	129.33±6.59	135±5.34	181±3.71	122±4.61
Atherogenic index	0.12±0.04	0.30±0.07	0.09±0.06	0.115 ±0.01	0.3 ±0.013	0.09±0.01
Adiponectin	14.98±1.60	14.7±1.88	12.86±0.96	15±1.34	10±0.55	13±0.96
Resistin	14.42±1.16	15.15±0.85	13.78±1.20	12±0.56	16±1.02	11±0.64
TNF-alpha	1.48±0.23	1.55±0.17	1.33±0.25	1±0.18	2±0.17	1±0.25

Table. 7 Evaluation of Biochemical parameter of phase II trials

Parameters	Beginning of the study			End of the study		
	Saline	Sugar	DPS	Saline	Sugar	DPS
Body weight	316±11.54	315±9.92	319±6.87	234±11.58	292±9.90	281±7.57
Food intake	55±0.85	54±0.71	58±1.54	33±1.47	25±0.61	65±1.07
Water intake	50±0.98	52±2.34	49±1.57	62±1.08	63±1.35	57±1.70
BGL	346±15.37	306±18.51	342±16.47	513±12.15	540±28.60	273±16.30
Insulin level	15.15±0.8	14.95±1.04	12.95±1.15	16.01±0.38	14.95±0.31	13.42±0.59

HDL	85.33±3.06	79.13±1.67	83.5±2.09	66±2.31	58±2.74	85±3.15
LDL	109.50±4.1	127.66±2.46	110.16±2.42	149±4.3 6	159±5.38	139±3.84
TG	113.50±6.45	125.50±3.72	111.17±3.94	106±8.11	146±6.13	102±5.90
TC	126.33±5.60	168.33±5.41	129.33±6.59	142±4.25	165±5.84	126±4.6 4
Atherogenic index	0.12±0.04	0.30±0.07	0.09±0.06	0.31±0.03	0.40±0.22	0.36±0.0 3
Adiponectin	14.98±1.60	14.7±1.88	12.86±0.96	11.86±0.63	10.2±0.62	10.87±2. 91
Resistin	14.42±1.16	15.15±0.85	13.78±1.20	16.94±0.85	18.72± 0.82	14.72±1. 42
TNF-alpha	1.48±0.23	1.55±0.17	1.33±0.25	1.93±0.16	1.88±0.20	1.52±0.2 0

Table 8. Individual Animal Observations for 14 days

Dose Level	Animal No.	Body weight			Mortality	Signs of toxicity			Gross necropsy
		Day 0 (gm)	Day 7 (gm)	Day 14 (gm)		Nature	Severity	Duration	
2000 mg/kg	H	230	240	235	No	NAD	NAD	NAD	NAD
	B	240	240	235	No	NAD	NAD	NAD	NAD
	T	230	240	240	No	NAD	NAD	NAD	NAD
Repeat dose 2000 mg/kg	H	280	280	290	No	NAD	NAD	NAD	NAD
	B	270	280	275	No	NAD	NAD	NAD	NAD
	T	250	250	245	No	NAD	NAD	NAD	NAD

NAD: No abnormality detected

Table 9. Individual Animal Cage Side Observations for dose level 2000 mg/kg

Animal ID	Observation parameters	Observation at Specific time Interval (hr)						
		0	0.5	1	2	3	4	24
H	Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil
B	Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Fur	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Tremor	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Diarrhoea	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Lethargy	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sleep	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Respiratory Pattern	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Behaviour	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mortality	Nil	Nil	Nil	Nil	Nil	Nil	Nil

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Figures:

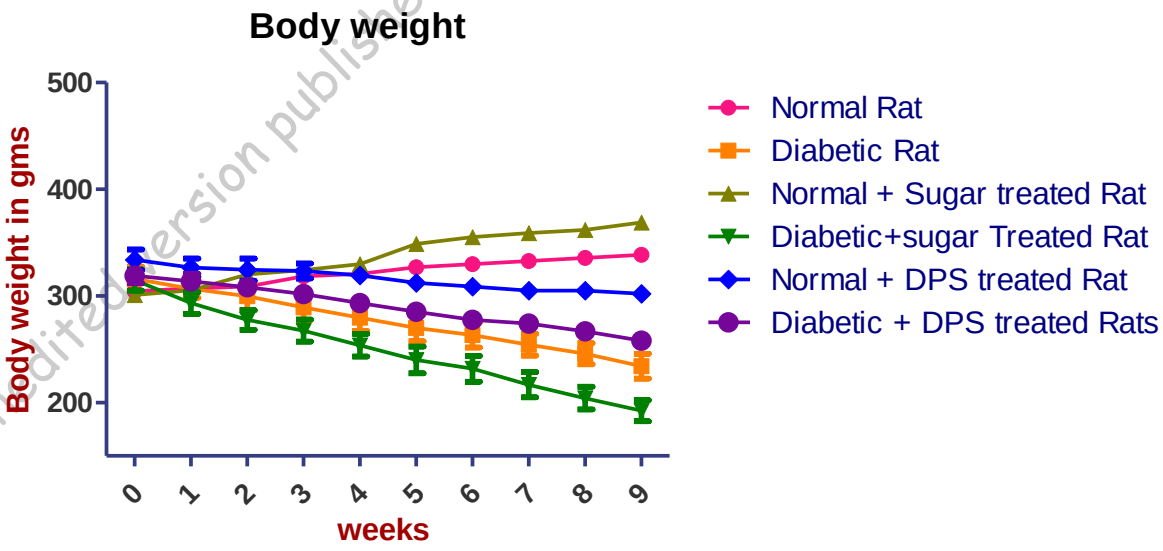

Figure 1. Effect of DPS on body weight

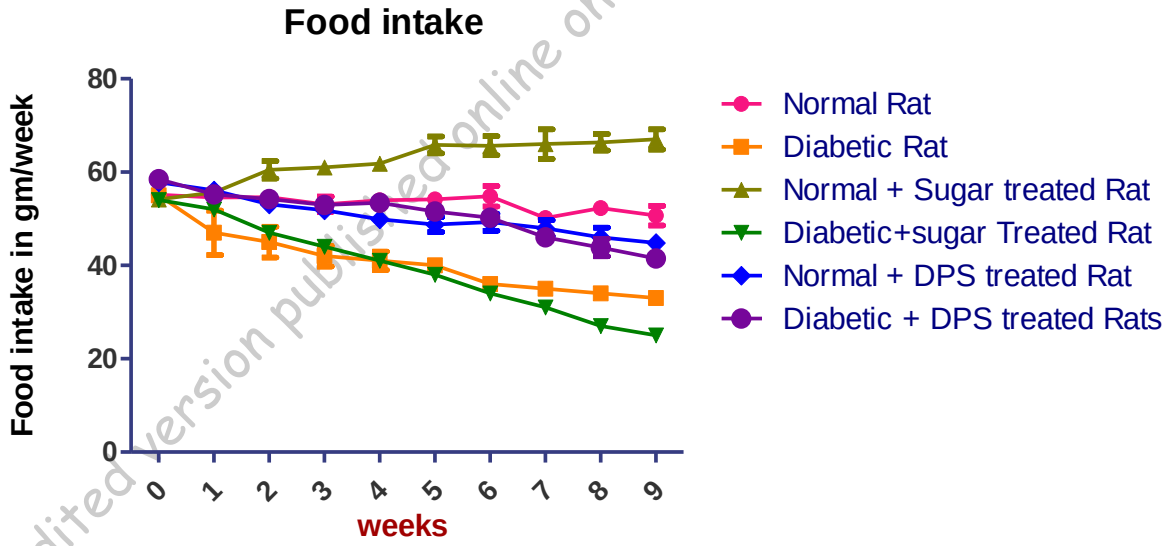

Figure 2. Effect of DPS on food intake

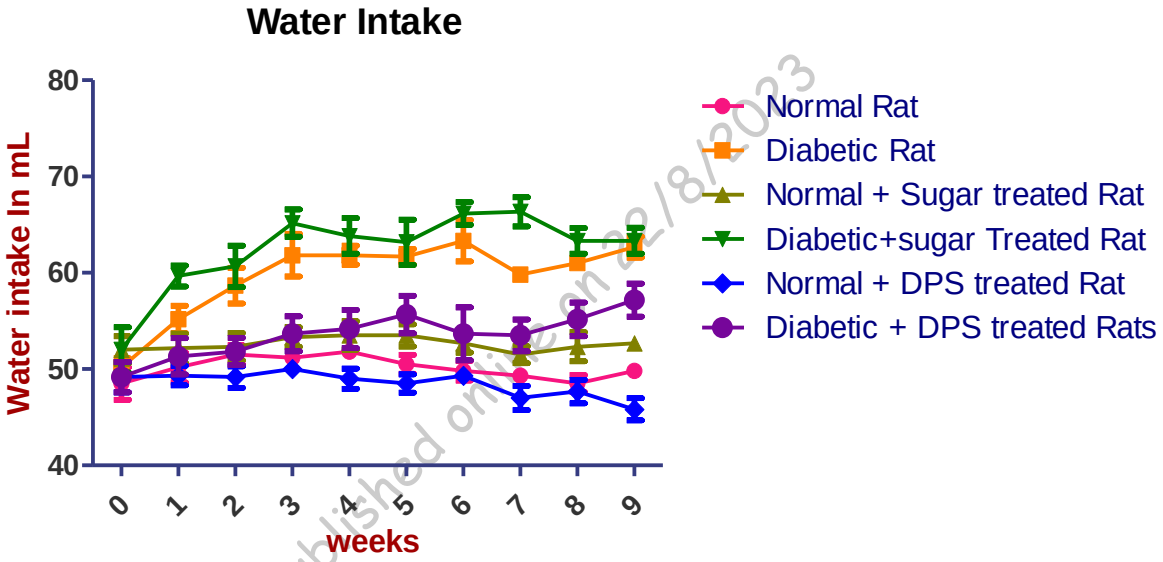

Figure 3. Effect of DPS on water intake

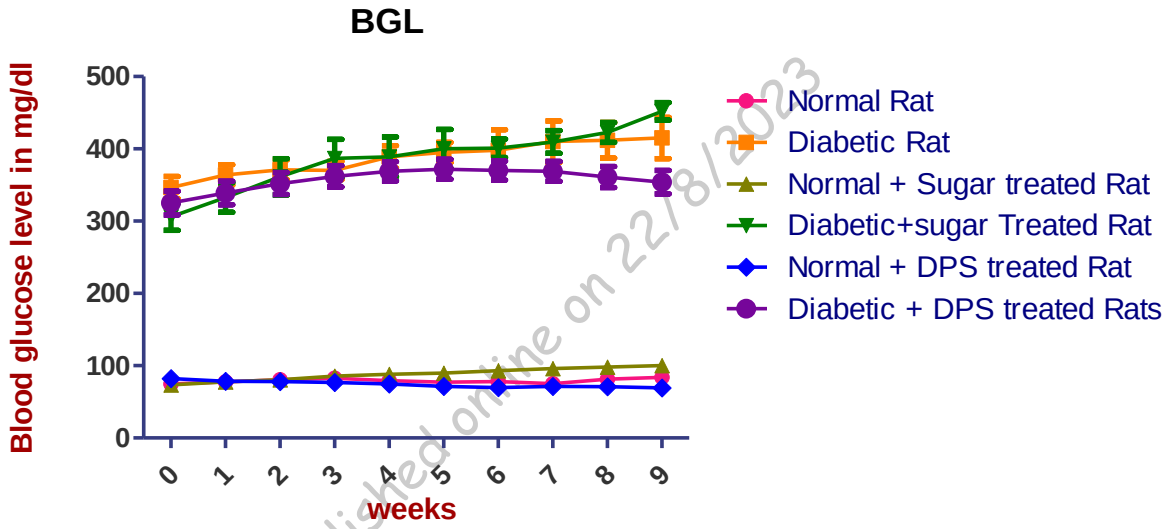

Figure 4. Effect of DPS on blood glucose level

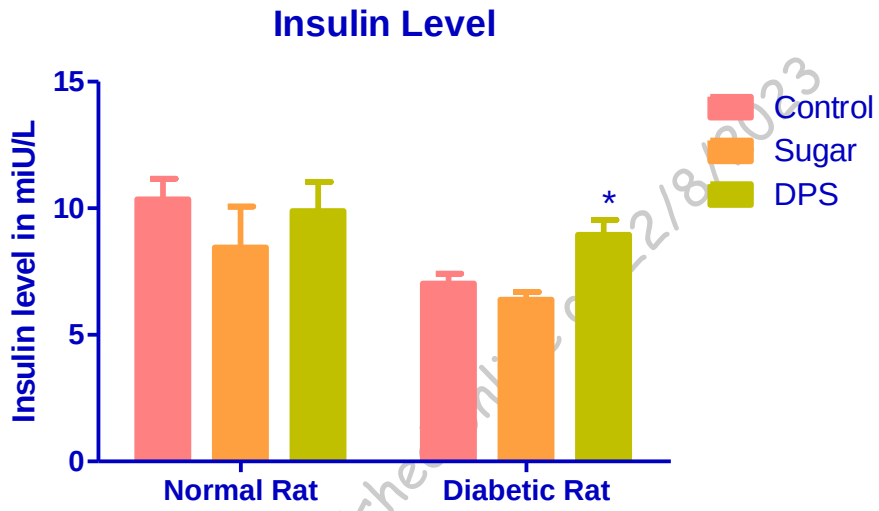

Figure 5. Effect of DPS on insulin level

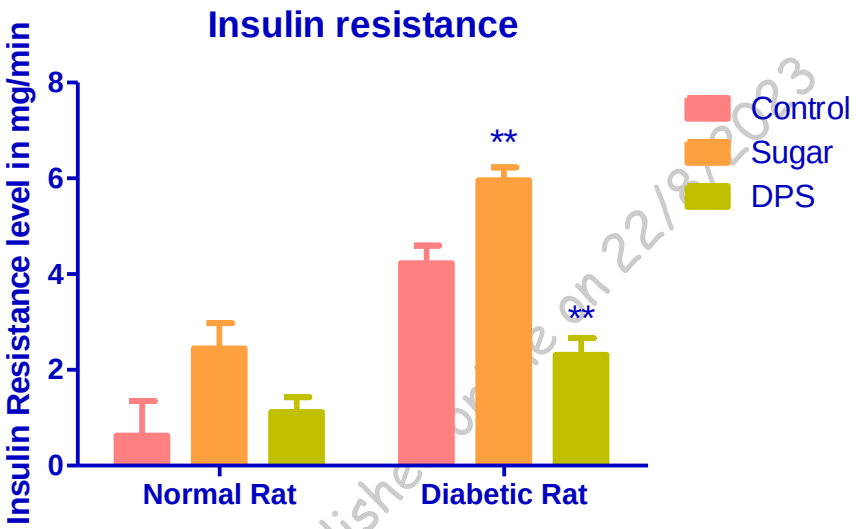

Figure 6. Effect of DPS on insulin resistance

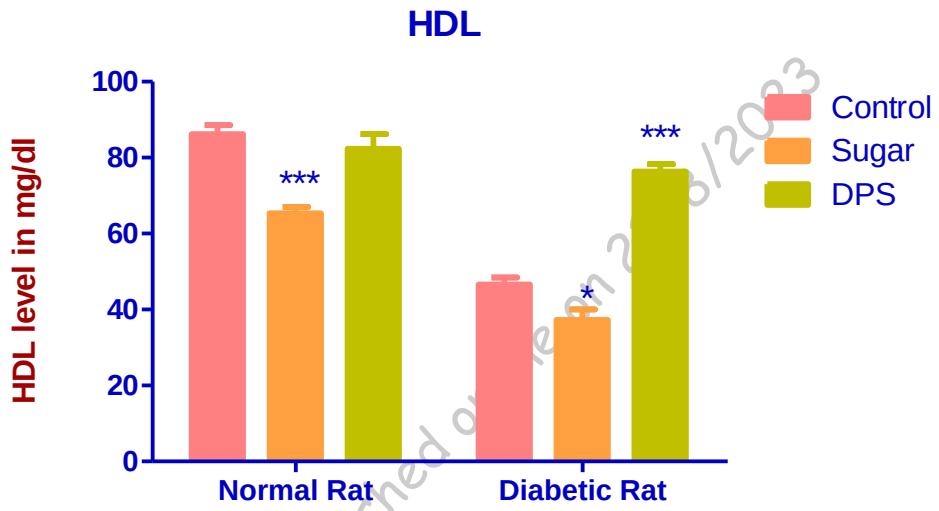

Figure 7. Effect of DPS on HDL level

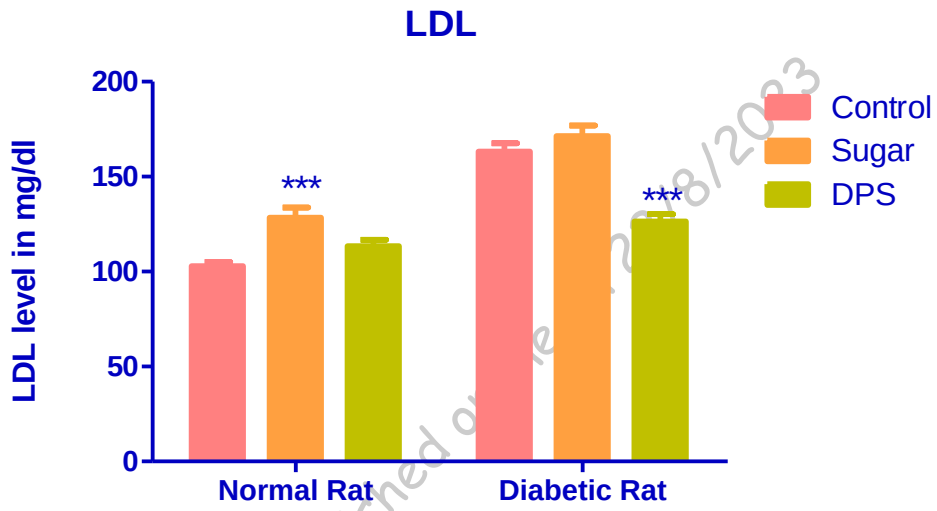

Figure 8. Effect of DPS on LDL level

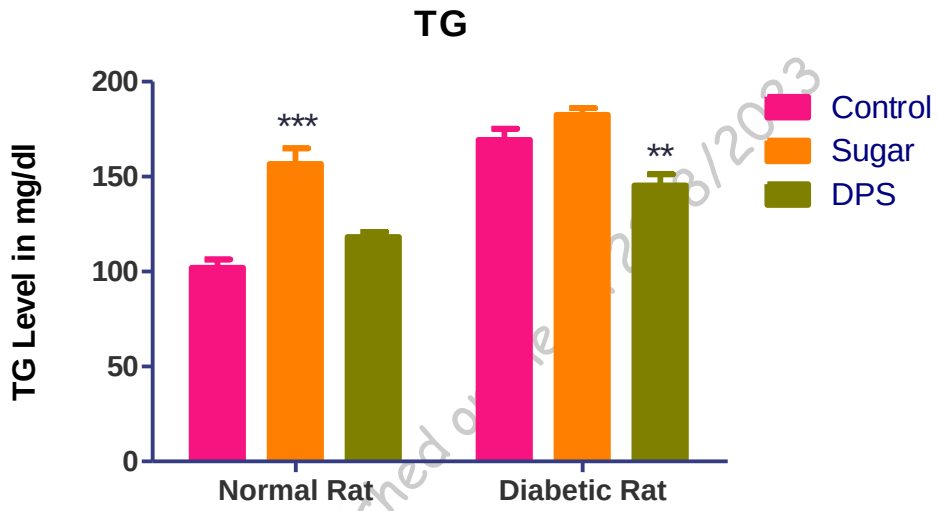

Figure 9. Effect of DPS on TG level

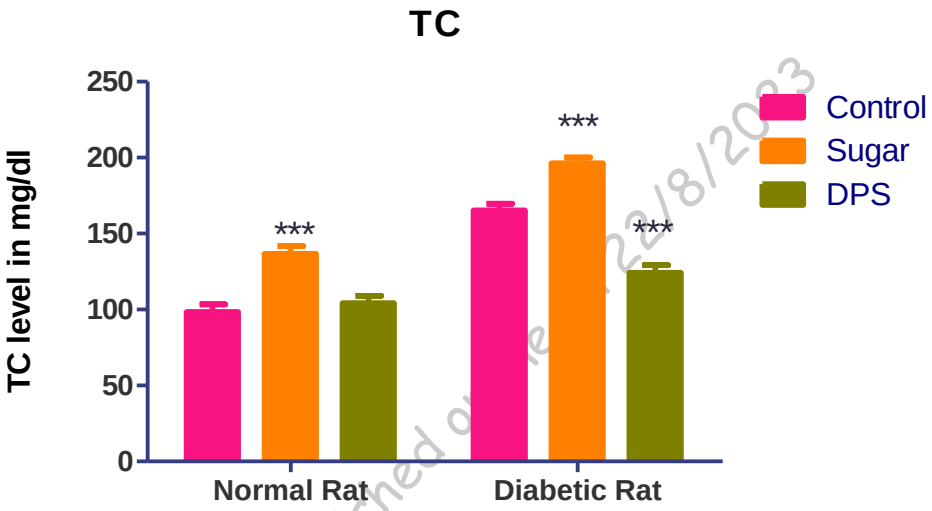

Figure 10. Effect of DPS on TC level

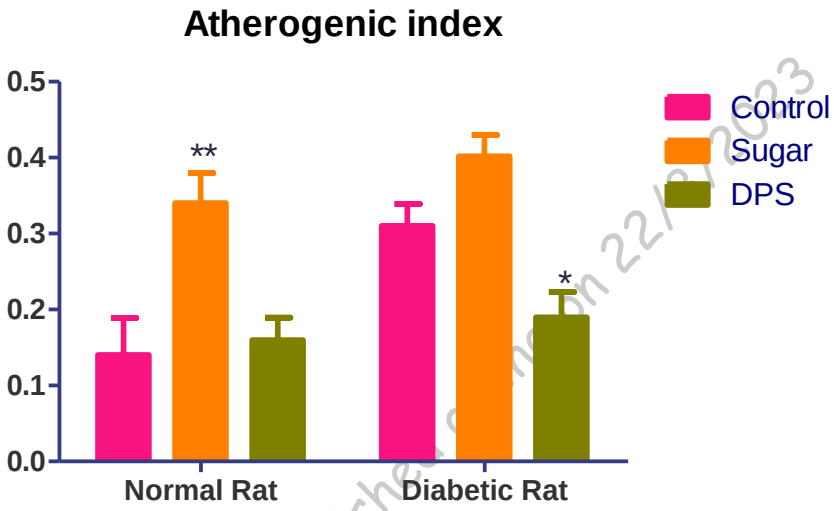

Figure 11. Effect of DPS on atherogenic index

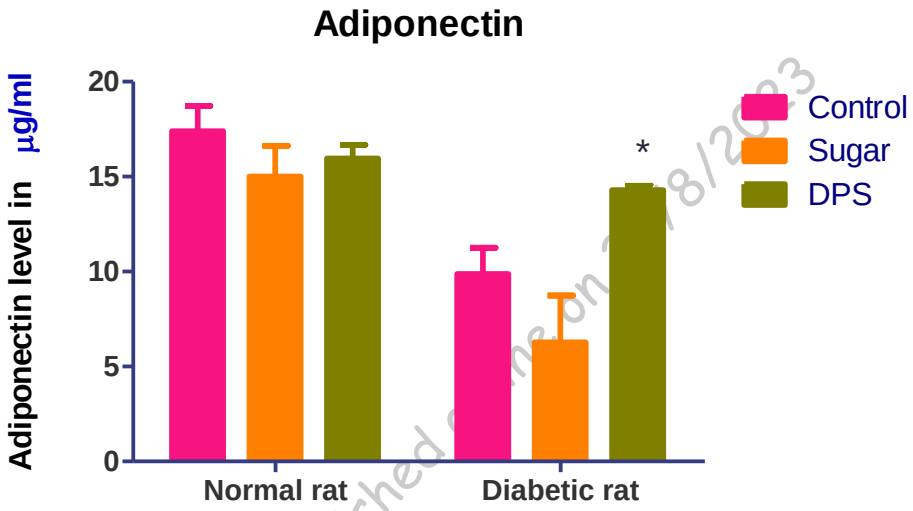

Figure 12. Effect of DPS on adiponectin level

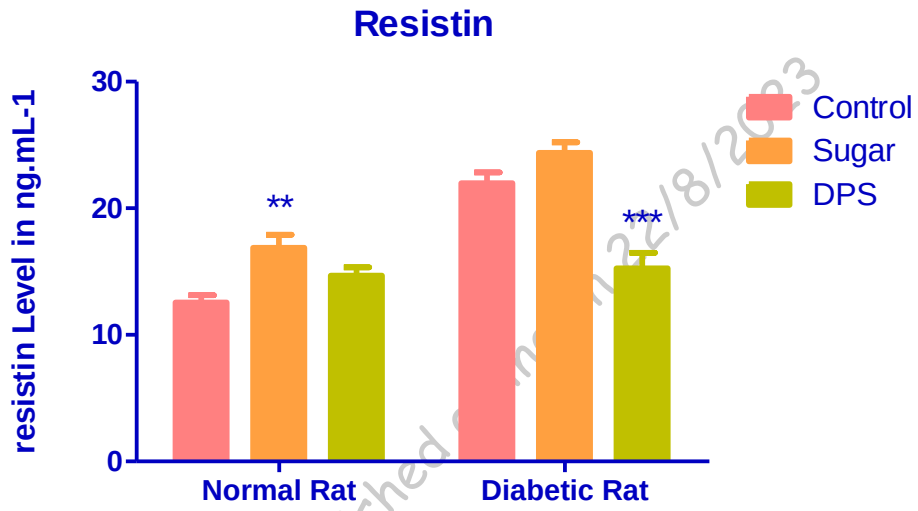

Figure 13. Effect of DPS on resistin level

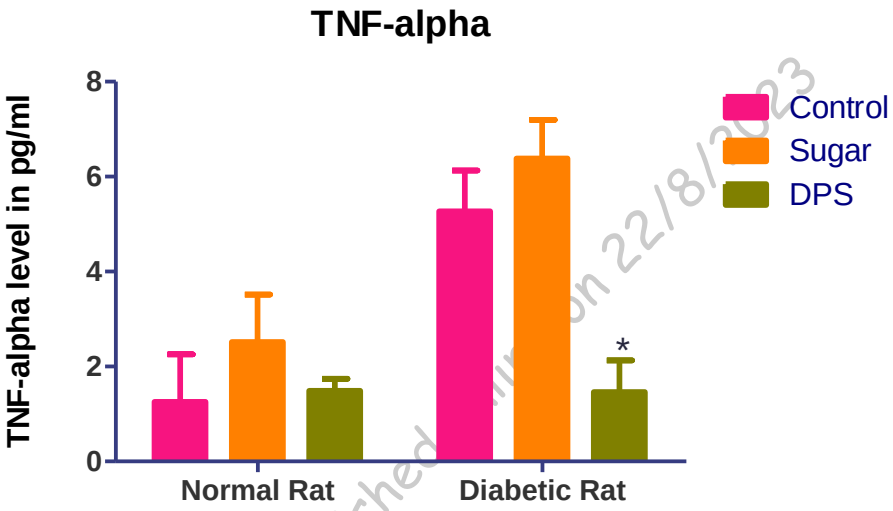

Figure 14. Effect of DPS on TNF-alpha level