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Effect of Fenugreek on Carbohydrate and Lipid Metabolisms of Rats Treated With Cypermethr in Combined With High-Fat-Diet and Low Dosestreptozotosin

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Abstract

The aim of the present study was to use the new model for the type 2 diabetes using high-fat diet (HFD) in combination with low dose of streptozotocin (STZ, 35mg/kg) and investgate the influences of cypermethr in (pesticide) toxicity which attenuated by fenugreek soaked seeds, etiolated sprouts (3 days old) and microgreen (10 days old) semi-modified diet (SMD) on experimental rats. From the obtained results, it can be indicated that the high fat feeding in combination with a low doses of STZ together with cypermthrin ingestion increased blood glucose and LDL-c in the paralled with decreasing rats body weight gain. The treatment by fenugreek etiolated sprouts (10%) semi-modified diet for HFD with STZ as semi-modified diets improved significantly the rats body weight gain (BWG) and lipids profile, while feeding on fenugreek microgreen readjusted significantly blood glucose, BWG, total cholesterol and HDL-c but decreased LDL-c levels. On the other hand, the using of soaked fenugreek seed semi-modified diets increased only BWG but decreased LDL-c. The hyperglycemia increased the total cholesterol content under the treatment with fenugreek microgreen semi-modified diets which showed more pronounced increment in combination with cypermethrin. The accomplished results showed that cypermethrin led to a hyperglycemic activity in HFD/STZ model rats. Soaking fenugreek seeds improved lipid metabolism compared with fenugreek and microgreen which non-toxic in doses given to rats in the present study over 28 days period.

Keywords: Cypermethrin**,** Fenugreek**,** Etiolated Sprouts**,** Microgreen**,** Streptozotocin**,** Albino rat.

Introduction

Induced diabetic models, of the experimental rats requires relatively high dose of streptozotocin (STZ> 50 mg/kg). Also, the hyperglycemia in these rats following STZ injection is primerly due to the direct pancreatic beta cell destructions and resulting insulin deficiency rather than the consequence of insulin resistance **(Shafrir, 2003).** Thus, they depict symptoms and characteristics typical more of human type 1 and type 2 and further are not responsive to the effect of anti-diabetic drugs **(Portha et al., 1994 and Singh et al., 2013).**

In contrast, the rats fed with high-fat diets develop obesity, hyper- insullinemia and insulin resistance and not frank hyperglycemia or diabetes, thus limiting the screening of agents on controlling the blood glucose level **(Storlien et al., 1986, Srinivasan et al., 2004 and Abdel-Rahim et al., 2009).** Thus the new type 2 diabetic rat mode developed by combining with feeding of high fat diets which produced insulin resistance and low dose of STZ injection. It caused the initial beta cells dis-function and subsequently the frank hyperglycemia (as preferred model) as reported by **Srinivasan et al., (2005)**. Pyrethroid pesticides such as cypermethrin (CM) in increasingly being used indoor pest control because of their high toxicity to insects and low toxicity to mammals. Cypermethrin (CM) is an important type II pyrethroid pesticide **(Verschoyle and Aldrige., 1980)** used extensively in pest control in the field. Pyrethroids reported to cause hepatotoxicity**(Abdel-Mobdy and Abdel-Rahim, 2015)**.

Animal studies have indicated that increased liver weight and liver function enzymes activity resulted hepatocellular hypertrophy, congestion and other microscopic changes **(Schoenig, 1995; Misra and Sharma, 1997 and Ishmael and Litchfield, 1988).** *In vivo* and *in vitro* studies have shown that CM induces hepatotoxicity and nephrotoxicity in experimental animals. **(Manna et al., 2005 and Abdel-Rahim et al., 2009).**

Several studies have indicated that pretreatment with antioxidant can ameliorate the toxicity of pyrethroids **(Aldana et al., 2001, Giray et al., 2001, Salah et al., 2010 and Abdel-Mobdy and Abdel-Rahim, 2015).**

Fenugreek seeds (*Trigonella foenum graecum*) is one of the oldest medicinal plants dating back to Hippoocrats and ancient Egyptian times **(Jensen, 1992).** Fenugreek seeds are a rich source of flavonoid compounds and many workers have reported the antioxidant potential of fenugreek **(Dixit et al., 2005; Kaviarasan et al., 2006; Randhir et al., 2004, Ravikumar and Anuradha, 1999).** Fenugreek contains saponins, glycosides and other beneficial chemical constituents **(Naidu et al., 2011)** which has pharmaceutical effects on pancreas and other tissues and improves glucose absorption, hyperlipidemic states as well as regulates insulin **(Raghuram et al., 1994; Prasanna, 2000 and Sauvaire et al., 1998).** Sprouting seeds for human consumption has been used for centuries in Egypt and Asian countries to improve food values.In forms of soaking and leaving seeds until they germinate and begin to sprout. This practice was reported to be associated with improvements in the nutritive value of seeds **(Abdallah, 2008).**

Insulin resistance is often associated with increased triglyceride (TG) and decreased HDL-c concentrations and increased LDL-c practices **(Singh et al., 2013)**.

The aim of the present study was investigated the influences of combination between diabetes, obesity and cypermethrin toxicity as well as evaluated the potentials as beneficial effects of soaked fenugreek seeds, etiolated sprouts and microgreen as semi-modified diets on blood glucose and lipid metabolites in normal and diseased intoxicated experimental rats .

Material and Methods

Fenugreek seeds were obtained from Agriculture Research Center, Giza. The seeds were cleaned from all impurities, for boiling soaked seeds (Hulba tea), and for etiolated sprout and microgreen production. Fenugreek etiolated sprout was done in glass jar methods for 3 days old as reported by **Abdallah (2008)**. While fenugreek microgreens were developed in open field and harvested after 10 days old from seed sowing. Bulk of boiling soaked seeds etiolated sprouts and microgreen were air dried for 3 days according to **Dzowela et al. (1995)** before crushed into powder for rats diets. Streptozotocin (STZ) was obtained from Biomedical, LLC. Palm oil was obtained from local market and cypermethrin formulation (Cyperco 20 % EC) was obtained from the Central Agriculture Pesticides Laboratory, Agriculture Research Center, Dokki-Giza-Egypt.

Experimental animals and diets:

The present study had been done using 50 male albino Spargue-Dawely rats with weight 140±10 g. The rats were provided by the animal house of the Egyptian Organization of Biological Products and Vaccines, Egypt. They were raised in the animal house of Biology Laboratory, Faculty of Agriculture, Cairo University, Egypt. The rats were divided into ten equal groups (5 rats each) and housed individually in stainless steel cages with wire mesh bottom and maintained 25±2°C, relative humidity of 50-60% and 12/12 h light/dark cycle throughout the experiment for a week for laboratory acclimatization. 45rats fed on high fat diets (HFD) which normal standard diet (AIN 76 diet) with addition 20% palm oil at the expense of corn oil and corn starch **Table (1)** *ad libilium* for the initial week period. After the week of HFD diets, 45 rats were injected intraperiotionally with low dose of STZ (35 mg/kg). Fenugreek semi-modified diets was prepared by addition of 10% level of boiling soaked, or etiolated sprouts or microgreen powders at the expense of corn starch as the American Institute of Nutrition Formulation (Ain-76 diets) **(Table 1)**.

Table 1. Composition diets (g/100 g) based on dry weight

Ingredients %	Control diet	HFD[2]	Fenugreek soaked, etiolated sprouts and microgreen diets
Casein	20	20	20
Corn starch	65	50	40
Mineral mix[1]	3.5	3.5	3.5
Vitamin mix[1]	1.0	1.0	1.0
DL-Methionine	0.3	0.3	0.3
Choline	0.2	0.2	0.2
Cellulose powder	5.0	5.0	5.0
Palm oil	5.0	20	20
Fenugreek soaked or etiolated sprouts or microgeen	-	-	10.0

1. Based on AIN-76 2. HFD = High fat diet

Experimental design

After the initial week period five groups of rats were oral toxified for 28 days according to **European Commission, (1996).** The 10 groups were detailed as follows:

G1 P_0T_0 : Normal health control rats fed on control diet .

G2 P_0T_1: HFD/STZ rats fed on HFD diet.

G3 P_0T_2: HFD/STZ rats treated by soaked seeds semi-modified diet

G4 P_0T_3: HFD/STZ rats treated by etiolated sprouts semi-modified diet

G5 P_0T_4: HFD/STZ rats treated by microgreen semi-modified diet

G6PT_0: Normal rats Fed on standard diet, served as pesticide (cypermethrin CM) intoxicated control by ingested with1/10 of LD_{50} of the pesticide

G7PT_1: HFD/STZ intoxicated cypermethrin (CM) rats (diseased/intoxicated control)

G8 PT_2: HFD/STZ intoxicated cypermethrin (CM)rats treated by soaked seeds diets

G9 PT_3: HFD/STZ intoxicated cypermethrin(CM) rats treated by etiolated sprouts diets

G10 PT_4: HFD/STZ intoxicated cypermethrin (CM)rats treated by microgreen diets

Blood samples collection and Analytical methods:
Blood samples were collected from fasting rats(12h) of each group from the retero oribital plexus of veins according to **Schermer (1967)** after 28 days in clean and sterile and labeled centrifuge tubes. Separating serum immediately was done by centrifugation at 1500xg for 5 min. Blood glucose was determined enzymatic colorimetrically in the serum according to the method of **Trinder (1969).**The serum total cholesterol (TC), low density lipoprotein cholesterol (LDL-c), and high density lipoprotein cholesterol (HDL-c) and triglycerides (TG) were determined with an automatic analyzer using diagnostic kit for each according to **Fossati and Prencipe. (1982) ; Allain et al., (1974); Wieland et al., (1983) and Burstein et al.,(1980)** respectively. While glucose was measured according to **Hugget and Nixon 1957.** Very low-density lipoprotein cholesterol (VLDL-c) was calculated by subdivision TG/5 according to **Fiedewald et al., (1972)**.The obtained data were statistically analyzed according to the method of **Snedecor and Cochran (1980)** and LSD (P<0.05) was used to compare the significant differences between mean of treatments.

Results and discussion

Concerning blood glucose levels measured before streptozotosin (STZ) injection (0 week) and at the end of the experiment (4 week that the experimental period) are illustrated in Table (2).The obtained results showed slight hyperglycemia for pesticide intoxicated group as comparing with to normal control during the studied period. Also, the achieved data showed body weight gain of normal and intoxicated experimental rats. From the obtained results found that pesticide ingestion significantly decreased the body weight with non-significant effect on body weight gain/100g intial body weight.

Table 2. Effect of cypermethrin pesticide ingestion on blood glucose levels, body weight and body weight gain on experimental rats**.**

Paramters / Pesticide	Blood glucose (mg/dl)		Body weight (g)		Body weight gain		
	Before STZ inj.	Final exp. (4 week)	Initial	Final	(g)	Per 100g intial body weight	%
Without pesticide	88.067A	155.70B	173.7a	226.04A	52.97A	30.50a	100
With pesticide (cypermethrin)	87.67A	186.35A	176.7a	207.68B	50.96A	28.84b	95
LSD 0.05	NS	17.451	NS	11.683	NS	1.44	

Means in each column of each group followed by the same letter are not significant different at the 5% level. NS = not significant

The high fat diet (HFD) feeding with low STZ in **Table (3)** showed significant hyperglycemia with fenugreek microgreen(T4) at the end of experiment which amounted to 203.38 mg/dl. The other groups treatments .i.e. with fenugreek etiolated sprouts recorded insignificant inceases in blood glucose levels which ranged between 160.5 and 172.88mg/dl after fenugreek microgreen, treatments compared to normal control (148.63 mg/dl). However, the low dose of STZ (35/mg) slightly produced hyperglycemia as compared with normal control. Similar data was reported by **Srinivasan et al., (2005)** they found that the high fat diet feeding with low STZ showed increase in the weight gain per100g of intial body weight under the treatment of soaked seeds.

Table 3. Effect of fenugreek semi-modified diets on blood glucose levels, body weight and body weight gain in experimental rats without cypermethrin as pesticide

Parameter / Diet	Blood glucose (mg/dl)		Body weight (g)		Body weight gain (g)	B.Wg/100g initial body weight	%
	Before STZ inj.	Final exp. (4 weeks)	Initial	Final			
Standard diet (T0)	87.17A	148.63B	167.8AB	214.10AB	46.30B	27.59C	100
HFD/STZ (T1)	88.00A	169.75B	167.5AB	199.10B	31.60C	18.87D	68
T2	87.50A	160.50B	177.1A	227.40A	50.33B	28.42C	103
T3	88.83A	172.88B	157.1B	218.50A	61.40A	39.08B	142
T4	87.83A	203.38A	155.0B	225.20A	70.20A	45.29A	164
LSD 0.05	NS	27.583	26.1	26.125	13.782	6.01	

Means in each column followed by the same letter are not significantly different at the 5% level.
NS = not significant

The interaction between cypermethrin pesticide and HFD/ STZ induction showed significant hyperglycemia either for G9 (HFD/STZ/CM+etiolated sprout semi-modified diet and G10 (HFD /STZ/CM treated by microgreen semi-modified diet) which those recorded 190.25 and235.5mg/dl respectively for glucose contents of serum, which were significant difference at the other treatment

The interaction between cypermethrin pesticide and HFD/STZ **Table (4)** also showed the same trend in the body weight gain. However, HFD/STZ without pesticide (G2) and with pesticide (G7) recorded the lowest body weight gain.

The decrease in the body weight gain of HFD/STZ, may be due to the rats catoblism of fats. However, HFD/STZ diabetic rats fed on fenugreek etiolated sprouts and microgreen semi-modified diet showed improvement in body weight gain which may be explained by increased insulin-like compounds and elevated consumption **(Amer et al., 2004, Taniguchi et al., 2007 and Tahany, 2015). Mansor et al. (2013)** reported that 30 mg/kg STZ dose induced weight loss especially the weight gain in the final weeks despite the continuation of the high fat diet, compared with the normal control.

Table 4. Effect of fenugreek semi-modified diets on blood glucose levels, body weight and body weight gain on experimental rats**.**

Group	parameter	Blood glucose (mg/dl)		Body weight (g)		Body weight gain		%
		Before STZ inj.	Final exp. (4 week)	Initial	Final	(g)	Per 100g initial body weight(g)	
Group 1	(POT0)	87.33a	140.25c	176.4a	230.00ab	53.60cb	30.39	100
Group 2	(POT1)	88.33a	163.50bc	174.0a	207.60abcd	33.60d	19.31f	64
Group 3	(POT2)	87.67a	148.00c	172.7a	232.00a	59.25b	34.31c	113
Group 4	(POT3)	89.00a	155.50bc	171.2a	231.20ab	60.00b	35.05c	115
Group 5	(POT4)	88.00a	171.25bc	171.0a	294.0ab	58.40ab	34.15c	112
Group 6	(PT0)	87.00a	157.00bc	159.2ab	198.20cd	39.00d	24.5e	81
Group 7	(PT1)	87.67a	176.00bc	161.0ab	190.60d	29.60d	18.39f	61
Group 8	(PT2)	87.33a	173.00bc	181.4a	222.80abc	41.40cd	22.82f	75
Group 9	(PT3)	88.67a	190.25b	143.0b	205.80bcd	62.80b	43.42b	145
Group10	(PT4)	87.67a	235.50a	139.0b	221.00ab	82.00a	58.99a	194
LSD0.05		NS	39.02	18.44	18.47	9.74	3.26	

Means in each column followed by the same letter are not significantly different at the 5% level.
NS= not significant
P0=without pesticide. P=with pesticide (CM).
T0=Normale controle. T1=High fat diet (HFD).
T2=High fat diet (HFD) +Fenugreek soaked seeds (10%).
T3=High fat diet (HFD)+Fenugreek etiolated sprout(10%).
T4=High fat diet (HFD)+Fenugreek microgreen (10%).

The feeding of HFD produced rats with insulin resistance syndrome as characterized by the increased body weight (obesity), mild hyperglycemia and compensatory hyperinsullinemia together with reduced glucose disappearance rate a condition similar to prediabetic, insulin resistance states in humans **(Reaven and HO, 1991 and Sirinvasan et al., 2004).** HFD has been shown to induce insulin resistance by different mechanisms but considered mainly though glucose fatty acid cycle **(Abdel-Rahim et al., 2009).** Briefly, the presence of high level of triglycerides due to excess fat intake could constitute as a source of increased fatty acid availability and oxidation. The preferential use of increased fatty acid for oxidation blunts the insulin-mediated reduction of hepatic glucose output and reduces the glucose uptake or utilization in skeletal muscle leading to compensatory hyper-insulinemia, a common feature of insulin resistance **(Belfiore and Iannello, 1998; Iwanishi and Kobayashi, 1993 and Rosholt and King, 1994)**. The increased body weight found in HFD rats might be due to the consumption of a diet rich in energy in the form of saturated fats and its deposition in various body fat pads **(Srinivasan et al., 2004)** and decreased energy expenditure as compared to normal pelts diet-fed animal **(Storlien et al., 1986).**

Table (5) showed serum lipid profile TC, TG, LDL-c, HDL-c and vLDL-c of the experimental rats ingested with or without cypermethrin pesticide which compared with normal rats. From the obtained results, serum TC, TG, HDL-c and vLDL-c showed insignificant values under the ingestion of CM as compared with normal control while LDL-c was increased in CM ingested rats (10.97 mg/dl) compared to that of normal control (9.55 mg/dl).

Table 5. Effect of cypermethr in pesticide ingestion on lipid profile of experimental rats

Parameter pesticide	Total cholesterol mg/dl	Triglyceride mg/dl	HDL-c mg/dl	LDL-c mg/dl	vLDL-c mg/dl
Without pesticide	79.60A	108.05A	48.30A	9.55B	21.61A
esticide (cypermethrin)	84.25A	102.85A	47.35A	10.97A	20.57A
LSD 0.05	NS	NS	NS	NS	NS

Means in each column followed by the same letter are not significantly different at the 5% level.
NS =Insignificant.

Concerning HFD/low STZ induction, data in **Table (6)** showed that HFD/STZ feeding diet without fenugreek significantly increased TC and LDL-c levels as compared with normal control .The other feeding treatments resulted insignificant effect on TG, HDL-c and vLDL-c. HFD/STZ fed on fenugreek soaked seeds diet (T3) decreased significantly TC (75.25 mg/dl) compared with HFD/STZ control (84.87 mg/dl) as well as HFD/STZ feeding with etiolated (T3) (91.5 mg/dl) or microgreen fenugreek (88.50 mg/dl). However, feeding HFD/DTZ with etiolated fenugreek sprouts (EFS T3) recoded significantly the higher TG (119 mg/dl) , LDL-c (14.25mg/dl) and vLDL-c (23.97 mg/dl) levels compared with other treatment. The feeding with microgreen(T4) increased HDL-c (52.50 mg/dl) compared with standerd diet but feeding with boiled soaked seeds and etiolated sprouts recorded significantly the lower HDL-c levels compared with microgreen and normal control.

Table 6. Effect of fenugreek semi-modified diets on lipid profile of experimental rats without cypermethrin as pesticide

Diet Parameter	Total cholesterol mg/dl	Triglyceride mg/dl	HDL-c mg/dl	LDL-c mg/dl	vLDL-c mg/dl
Standard diet (T0)	69.50B	95.50B	48.25B	5.75C	19.50B
HFD/STZ (T1)	84.87A	109.125B	47.125BC	14.25A	21.82AB
T2	75.25B	103.250B	45.625C	7.375BC	20.65B
T3	91.50A	119.815A	45.625C	14.25A	23.97A
T4	88.50A	97.500B	52.50A	9.28B	19.50B
LSD at 0.05	7.744	15.128	21.612	2.071	3.026

Means in each column followed by the same letter are not significantly different at the 5% level
NS = in significant

Regarding to the interaction between the CM pesticide and low dose STZ feeding with high fat diet treated by fenugreek semi-modified diets, data in **Table (7)** showed lower TC content for normal control than HDF/STZ control, while fenugreek etiolated sprouts and microgreen semi-modified diet ingested by CM pesticide recorded higher TC levels than that of normal control . However , CM pesticide interact with HFD and low dose STZ fed on etiolated fenugreek sprouts semi-modified diet decreased TG, LDL-c and vLDL-c levels compared with those of normal control.

The microgreen fenugreek semi-modified diet interacted with or without CM ingestion recorded higher HDL-c levels than the other treatments.

Table 7. Effect of fenugreek semi-modified diets on lipid profile of experimental rats

Group	Paramter	Total cholesterol (mg/dl)	Triglyceride (mg/dl)	HDL-c (mg/dl)	LDL-c (mg/dl)	VLDL-c (mg/dl)
Group 1	(POT0)	69.75e	100.75bc	46.00de	5.25de	20.15cb
Group 2	(POT1)	84.75bc	112.30bc	47.00cde	.6.00de	22.45cb
Group 3	(POT2)	73.50ed	92.25c	51.00ab	3.75e	18.45c
Group 4	(POT3)	84.00bcd	140.75a	43.75ef	22.00a	28.15a
Group 5	(POT4)	86.00bc	94.25bc	94.25bc	53.75a	10.75bc
Group 6	(PT0)	85.00bc	94.25bc	50.50abc	6.25de	18.85cb
Group 7	(PT1)	69.25e	106.00bc	47.25cde	23.25a	21.20cb
Group 8	(PT2)	77.00e	114.25b	40.25f	11.00b	22.85b
Group 9	(PT3)	99.00a	99.00bc	47.50bcd	6.50de	19.80cb
Group 10	(PT4)	91.00ab	100.75bc	51.25a	7.82cd	20.15cb
LSD at 0.05		10.951	21.94	3.6935	2.929	4.2787

Means in each column in each group followed by the same letter are not significant different at the 5% level
NS = not significant

The abnormal high concentration of serum lipids in fenugreek etiolated sprouts-semi-modified diet feeding for HFD/STZ rats may be due to mainly to an increase in the mobilization of free fatty acid from the peripheral fat depots, since insulin inhibits the hormone-sensitive lipase as reported by **Pushparaj et al., (2000).** Excess fatty acids in serum of diabetic rats are converted into phospholipids and cholesterol in the liver **(Murray et al., 2012).** These two substances along with excess triglycerides formed at the same time in the liver may be discharged into the blood in the form of lipoproteins **(Bopanna et al., 1997).**

From the above methodical results, it can be concluded that soaked fenugreek seeds can use as antidiabetic, antiobesity and antitoxicity agents against the harmful of STZ/ HFD combined with cypermethrin induction.

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تاثير الحلبة علي التمثيل الغذائي للكربوهيدرات والدهون في الجرذان المعاملة بالسيبرمثرين مع التغذية عالية الدهون والمحقونة بجرعة منخفضة من الاستربتوسيتوزين

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تهدف هذه الدراسة لإستخدام النموذج الجديد لمرض السكري من النوع الثاني باستخدام التغذية مرتفعة الدهون بالاشتراك مع الجرعة المنخفضة من الاستربتوسيتوزين (٣٥ ملجم/ كجم) لدراسة تأثيرات سمية مبيد السيبرمثرين وعلاج هذه التأثيرات عن طريق البذور المنقوعة من الحلبة ونبت الظلام بعمر ثلاثة أيام والبادرات الخضراء بعمر عشرة أيام كجزء من مكونات عليقة نصف معدلة للجرذان المصابة. استخدام التغذية مرتفعة الدهون مع الجرعة المنخفضة في الاستربتوسيتوزين والمعاملة مع مبيد السبيرمثرين أدت إلى زيادة في مستوى السكر في الدم وزيادة الليبوبروتين منخفض الكثافة مع انخفاض في وزن الجرذان ولكن إضافة نبت بذور الحلبة في الظلام بنسبة ١٠% كجزء من مكونات العليقة للنموذج مرتفع الدهون مع الجرعة المنخفضة من الاستربتوسيتوزين أدى إلى زيادة معنوية في وزن الجرذان والزيادة المكتسبة للوزن والكوليسترول الكلي والجلسريدات الثلاثية بينما أدت إضافة بادرات الحلبة الخضراء كجزء من مكونات العليقة إلى زيادة معنوية في سكر الدم ووزن الجرذان والزيادة المكتسبة في الوزن والكوليسترول الكلي والليبوبروتين مرتفع الكثافة ولكنها أدت إلى إنخفاض الليبوبروتين منخفض الكثافة ومن ناحية أخرى أدت إضافة بذور الحلبة المنقوعة كجزء من مكونات العليقة لزيادة في وزن الجرذان والزيادة المكتسبة في الوزن كذلك إنخفاض في الليبوبروتين منخفض الكثافةو الزيادة في الكوليسترول الكلي. كما اوضحت النتائج ان تأثيرات نتيجة إضافة البادرات الخضراء للحلبة كانت أكثر وضوحاً في الجرذان المعاملة بمبيد السيبرمثرين . كما أظهرت النتائج أن السيبرمثرين له تأثير رافع لنشاط تأثيرات المرض في نظام التغذية مرتفعة الدهون مع الجرعة المنخفضة مع الاستربتوسيتوزين بينما إضافة بذور الحلبة المنقوعة أدت إلى تحسين التمثيل الغذائي للدهون بالمقارنة مع نبت الظلام و البادرات الخضراء للحلبة كجزء من مكونات العليقة .

ويمكن التوصية من هذه الدراسة بأن بذور الحلبة المنقوعة يمكن استخدامها كمواد مضادة لمرض السكري ومكافحة السمنة وكذلك مضادة للسمية في نظام التغذية مرتفعة الدهون مع الجرعة المنخفضة من الاستربتوسيتوزين والمرتبطة مع احداث مبيد السيبرمثرين . كماالتضح ان النسبة المضافة من الحلبة للعليقة أنها غير سامة في الجرعة المستخدمة للجرذان لمدة ٢٨ يوم وهى فترة الدراسة.