تأثير التغذية بخل البلسميك علي الفئران المصابة بالسمنة

د. أماني احمد عبد العزيز، د. إبراهيم محمد عبدالرزاق،

د. اسامه السيد مصطفي، أ. رقيه محسن سرحان

قسم الاقتصاد المنزلي كليه التربية النوعية جامعه جنوب الوادي

مصر

مجلة البحوث في مجالات التربية النوعية

معرف البحث الرقمي DOI: 10.21608/jedu.2022.121019.1601

المجلد الثامن العدد 42 . سبتمبر 2022

الترقيم الدولي

P-ISSN: 1687-3424 E- ISSN: 2735-3346

موقع المجلة عبر بنك المعرفة المصري https://jedu.journals.ekb.eg/

موقع المجلة http://jrfse.minia.edu.eg/Hom

العنوان: كلية التربية النوعية . جامعة المنيا . جمهورية مصر العربية

Effect of consumption balsamic vinegar on obese rats

Amany Ahmed Abd El-Aziz[1]

Ibrahim Mohamed Abd – Elrazik[1]

Usama El-Sayed mostafa[2]

Rokaya Mohsen Sarhan[1]

1 Home Economics Department, Faculty of Specific Education, South Valley University, Egypt

2 Home Economics Department, Faculty of Specific Education, Ain Shams University, Egypt

Abstract:

This study was conducted to investigate the effect of different concentrations consumption of balsamic vinegar on obese experimental rats., 40 male albino rats, with an average initial weight of 160 g, were divided into 5 groups (8 rats/group). Group (1), fed on basal diet, while the other four group fed on high-fat diet for six weeks to induce obesity. Group (2), was kept as a positive control group, while rats of group (3, 4 and 5) were given levels (0,75 ،1.5 and 3%) of balsamic vinegar solution for 6 weeks, respectively. Results showed that balsamic vinegar consumption led to reduction of body weight in all groups consumed balsamic vinegar solution. There were significant reduction between rats of group (2) and the three treated groups in levels of total cholesterol, triglycerides, VLDL and LDL, while the level of HDL was high in the three treated groups. Both kidney function and liver enzymes were improved in obese rats that consumed balsamic vinegar solution. It concluded that balsamic vinegar has an excellent nutritional beneficent and protection against obesity.

Key words: balsamic vinegar, obesity, lipid profile, liver enzymes, kidney functions.

INTRODUCTION

Obesity has become a critical challenge worldwide in the recent decades and is associated with many public health problems such as dyslipidemia, cardiovascular disease, and type 2 diabetes **(Al-Kuraishy and Al-Gareeb, 2016; Heart, 2000)**. An estimated 650 million adults, 13% of the world's adult population were obese in 2016, and 19.7% of the world's population will be obese by the year of 2030 **(Štimac *et al.*, 2020)**.

Obesity is an epidemic disease caused by multiple endogenous and environmental factors. Among these factors, excessive caloric intake, particularly from energy-dense meals, is thought to be the main factor contributing to global obesity **(Wisse *et al.*, 2007)**.

The most effective strategies for the management of obesity are energy intake restriction, increased physical activity, behavioral modifications, pharmacotherapy and bariatric surgery (**Heart, 2000)**. Unfortunately, these treatments have had a maximum success rate of only 21% (**Wing and Hill, 2001**).

Various inhibitor drugs for the treatment of obesity are specifically effective in acting on targeted metabolic diseases, however, these drugs often have side effects such as insomnia, headache, palpitation, irritability, agitation, nervousness, stroke, heart attack, flatulence, diarrhea, abdominal pain, bloating, nausea, dyspepsia, arthralgia, dizziness, constipation, and dry mouth **(Mohamed *et al.*, 2014).**

Traditional and complementary medicine is becoming more popular worldwide generally due to fewer side effects **(Ajaykumar *et al.*, 2012)** Fermented alcoholic beverages such as vinegar were rich sources of unique organic compounds and secondary metabolites, vinegar contains polyphenols, which display antioxidant qualities in the body, polyphenols found in the acetic acid of vinegar also inhibit microbial growth (**xu *et al.*, 2007**). Vinegar is known for its antioxidative anti-tumor

proliferative properties (**Fukuyama *et al.*, 2007),** and for lowering blood lipid levels **(Fushimi *et al.*, 2006).** Vinegar administrationhas favorable effects on anthropometric parameters especially body weight Furthermore, the effects of vinegar on lipid parameters in previous studies were contradictory (**Kondo et al., 2009; Lim et al., 2009; Ok et al., 2013; Seo et al., 2014)**; additionally, the effects of vinegar on lipid parameters in previous studies were contradictory (**Kondo et al., 2009; Lim et al., 2009; Ok et al., 2013; Seo et al., 2014). (Kondo et al., 2009; Ok et al., 2013; Park et al., 2014; Seo et al., 2014).**

As a result, the current study looked into the effects of varied doses of balsamic vinegar consumption on obese experimental rats.

MATERIALS AND METHODS

40 male albino rats, with an average initial weight of 160g, were obtained from the Egyptian Company for Production of Antisera, Vaccines and Drugs Helwan, Egyptian.

Induction of Obesity:

Obesity was induced in rats according to **Bhatt *et al.*, (2006)** by feeding on high fat diet (fat beef tallow) for 40 day that supplied 45% calories to induce obesity.

Experimental animals:

Forty White Albino male rats (Sprague Dawley strain) (average body weight 160g) were obtained from the Egyptian Company for Production of Antisera, Vaccines and Drugs Helwan, Egyptian. Rats were housed individually in wire cages under the normal laboratory conditions and fed on the basal diet for a week as adaptation period.

Experimental design:

Rats were divided into 5 groups (8 rats/group). Group (1), was kept as a negative control group(- ve) and fed on basal diet, while the other four group fed on high-fat diet for 40 days to induce obesity. Group (2), was kept as a positive control group(+ve), while rats of group (3, 4 and 5) were given levels (0,75 ,1.5 and 3%) of balsamic vinegar solution for 6 weeks, respectively. as following:

Group(1): (8 rats) Served as negative control and received basal Diet, which was consisted of 10% casein, 10% corn oil, 1% vitamins mixture, 4% minerals mixture, 0.2% choline chloride, 5% cellulose, methionine 0.3% and 69.5% corn starch as described by **(AIN., 1993)**.

Group(2): (obese rats): the second main group was contained 32 rats that fed on high-fat diet (fat beef tallow) for 40 day that supplied 45% calories to induce obesity **(Bhatt *et al*., 2006)**. That group was divided into 4 sub-groups, each group contained (8 rats) as following:

Sub-group 1: obese rats that were kept as a positive control group fed on basal diet as the first main group.

Sub-group 2: fed on basal diet as the first main group and treated with 75% of balsamic vinegar solution.

Sub-group 3: fed on basal diet as the first main group and treated with 1.5% of balsamic vinegar solution.

Sub-group 4: fed on basal diet as the first main group and treated with 3% of balsamic vinegar solution.

After the end of the experimental period (6 weeks) of treating by balsamic vinegar solution, rats were fasted overnight, and blood samples were collected from the reto orbital plexus from all animals of each group into clean, dry and labeled tube. Blood samples were left to clot at room temperature, then serum was separated by cooling centrifugation (-3°C) at 5000 rpm for 10 minutes. Serum samples were stored at -20°C until biochemical assays.

Biological Evaluation:

Determination of Body weight (BW):
Body weight (BW) and Body weight gain% (BWG %) were measured weekly according to **Chapman *et al*., (1959)**

Determination of serum total cholesterol:

Serum total cholesterol (TC) was determined according to **Deeg and Ziegenhorm, (1983), Artiss and Zak, (1997)**.

Determination of serum triglyceride:
triglycerides (T.G) was determined according to **Guder and Zawat, (2001)**.
Determination of very low density lipoprotein (VLDL) cholesterol: very low density lipoprotein (VLDL) cholesterol was determined according to **Gazi et al.,(2006).**
Determination of low-density lipoprotein (LDL) cholesterol:
low density lipoprotein (LDL) was determined according to **Lopes *et al*., (1977**).
Determination of high-density lipoprotein (HDL) cholesterol:
high density lipoprotein (HDL) cholesterol was determined according to **Friede Wald et al., (1972)**.
Determination of serum aspartate amino transferees activity (AST/GOT) and alanine amino transferees activity (ALT/GPT):
Serum AST (GOT) and ALT (GPT) activities were measured according to the method described by **Yound, (1975**). **Determination of alkaline phosphates (ALP):**

Serum alkaline phosphates activities (ALP) enzyme was estimated according to **Belfield and Goldberg, (1971).**

Determination of Uric Acid :
Uric acid value was determination according to **Young (2001)**.
Determination of Serum Urea Nitrogen:
Urea level was determination by **Thomas, (1998) and Brith *et al*., (1999)** method.

Statistical analysis

Statistical analysis using one-way analysis of variance (ANOVA) was done to compare between Negative control group, Positive control group and group treated, followed by post-hoc analysis (Duncan's test) using Statistical package for Social Science (SPSS, 20), data were expressed as mean±(SD) standard deviation for five rats in each group **(Coakes, 2012)**.

RESULTS AND DISCUSSION

Effect of consumption of three levels of balsamic vinegar solution on BW of obese rats

Rat's body weight (BW) was recorded weekly; As noticed from Table (1) result revealed that, the mean values of initial rats body weights for Control (-Ve), Control (+Ve), Group (3) , Group4 and Group5 were recorded , 161.0±6.2 , 168.3±8.4, 164.6±5.6, 166.8±7.7, 163.5±5.9(g); respectively. The statistical analysis reflected that there were no significant differences between the 5 groups in the initial body weights.

After six weeks of inducing obesity, the mean values of body weights of; group1 (negative control), group2(fed on high-fat diet as positive control), group3(treated group fed on high-fat diet plus 75% of balsamic vinegar solution), group4(treated group fed on high-fat diet plus 1.5% of balsamic vinegar solution), group5(treated group fed on high-fat diet plus 3% of balsamic vinegar solution) were recorded; 178.5±4.8, 228.4a±7.5, 223.6±5.9, 218.0±4.3 210.3±6.7(g); respectively. Results in the same table showed that obese rats groups recorded the highest weights compared with the healthy control (-ve) group after six weeks of experiment. The statistical analysis referred that there were significant differences ($p<0.1$) between the obese groups and healthy control (-ve) group rats in weights after 6 weeks. On the other hand there was no significant differences between the all groups of obese rats.

After the end of the experimental period (6 weeks) of treating by balsamic vinegar solution ,the mean values of final body weights for treated obese rats (group3, group4, group5) and untreated group2 were recorded; 297.6b±7.8, 261.4±6.2, 218.2±8.2 and , 342.0±9.4g respectively while negative control group(1) fed on basal diet recorded 209.2±4.3 g. The findings of this study show that balsamic vinegar reduced body weight of all groups that treated with it. such results agreed with **Kondo *et al*., (2009**) who indicated that active compounds in vinegar (acetic acid) help to reduce body weight of high-fat-fed mice by suppressing body fat. Vinegar may aid in weight management, which could reduce obesity and help prevent the onset of chronic disease, such as metabolic syndrome, cardiovascular disease, and diabetes. **Ajaykumar**, ***et al.,*** **(2012)** observed a decrease in body weight in ACV−treated animals compared to hyperlipidemia−induced mice indicating a protective effect of apple cider vinegar (ACV)against hyperlipidemia.

Bouazza et al., **(2016)** show that Administration of fruit vinegars significantly decreased $(p \leq 0.05)$ body weight gain

Table (1): Effect of consumption of three levels of balsamic vinegar solution on BW of obese rats

Rats group	BW		
	Initial weight Mean (±)SD	After 6 weeks Mean (±)SD	Final weight Mean (±)SD
Group (1)	161.0^{a}±6.2	178.5^{b}±4.8	209.2^{d}±4.3
Group (2)	168.3^{a}±8.4	228.4^{a}±7.5	342.0^{a}±9.4
Group (3)	164.6^{a}±5.6	223.6^{a}±5.9	297.6^{b}±7.8
Group (4)	166.8^{a}±7.7	218.0^{a}±4.3	261.4^{c}±6.2
Group (5)	163.5^{a}±5.9	210.3^{a}±6.7	218.2^{d}±8.2

Values are expressed as mean ±SD Values at the same column with different letters are significant at($p<0.05$)

Effect of consumption of three levels of balsamic vinegar on lipid profile in obese rats

Data in Table (2) revealed that there were significant increase at (P<0.05) in total cholesterol (TC), triglyceride (TG) , LDL-cholesterol , VLDL- cholesterol, while HDL- cholesterol levels reduced significantly (p <0.05) in positive control group, as compared with negative control group. The results obtained from Table (2) revealed that after consuming the three concentrations from balsamic vinegar, total cholesterol (TC), triglyceride (TG), LDL-cholesterol, VLDL-cholesterol were significantly reduced (p<0.05), but HDL-cholesterol levels significantly increased for groups (3, 4, and 5) as compared with positive control group(2).

The highest impact in decreasing of total cholesterol (TC), triglyceride (TG) , LDL- cholesterol , VLDL- cholesterol and increasing in HDL- cholesterol levels were recorded for the group(5), which treated with higher level of balsamic vinegar 3%. These results were similar with **Beheshti *et al.*,(2012)** who reported that vinegar can significantly reduce the concentration of total cholesterol, triglycerides, and low-density lipoprotein cholesterol (LDL-c), and increase the concentration of high-density lipoprotein cholesterol (HDL-c).

Ajaykumar *et al.*,(2012) who reported significantly(P<0.01) reduced in the elevated levels of TC, TG, LDL and VLDL in hyperlipidemia rats that Oral consumption of ACV and significant (P<0.01) increase in HDL-C values.

On the other hand, **Moon and Cha (2008)** reported that the dietary intake of vinegar has been lowering triglyceride levels.

Khezri, *et al.*,(2018) reported that ACV reduced the levels of fat blood such as triglycerides , total cholesterol , high density lipoprotein-cholesterol, malondialdehyde , blood

glucose and increase level HDL-c in rats. The decreasing of TC and TG may be due to balsamic vinegar contain high amount of total acetic acid, antioxidant compounds as stated by **Hutchins, (2019)** who showed that vinegar contains polyphenols, which display antioxidant qualities in the body. Polyphenols found in the acetic acid of vinegar.

However, the decreased of serum LDL-c, VLDL- may be due to alkaloids and flavonoids.

Chou *et al*., (2015) reported that Black vinegar (BV) contains abundant essential and hydrophobic amino acids, and polyphenolic contents, especially catechin and chlorogenic acid. In chemical analyses K and Mg are the major minerals in BV contributed the lipid lowering and have antioxidant effects.

Shafi and Tabassum (2019) reported that the explanation of reduce in serum low density lipoprotein cholesterol, serum very low density lipoprotein cholesterol level and increase of serum high density lipoproteins cholesterol after administration of balsamic vinegar extract may be due to presence of glycosides, alkaloids and flavonoids.

Table (2): Effect of consumption on three levels of balsamic vinegar solution on biomarker for lipids profile of obese rats

Rats group	CHO. (mg/dl)	TG (mg/dl)	VLDL (mg/dl)	LDL (mg/dl)	HDL (mg/dl)
	Mean (±)SD	Mean (±) SD	Mean (±)SD	Mean (±)SD Mean (±)SD	Mean (±)SD
Group (1)	98.8^{e}±5.2	91.6^{d}±10.3	18.3^{d}±2.0	24.5^{e}±5.8	56.0^{a}±4.4
Group (2)	141.8^{a}±7.1	129.1^{a}±8.1	25.8^{a}±1.6	83.4^{a}±5.2	32.6^{e}±5.8
Group (3)	125.8^{b}±11.0	118.6^{b}±6.1	23.7^{b}±1.2	62.7^{b}±9.6	39.4^{d}±5.2
Group (4)	113.6^{c}±10.9	115.8^{b}±9.4	23.1^{b}±1.8	43.9^{c}±4.7	46.6^{c}±6.0
Group (5)	107.6^{d}±7.9	106.6^{c}±4.5	21.3^{c}±0.9	34.3^{d}±2.0	52.0^{b}±3.5

Values are expressed as mean ±SD Values at the same column with different letters are significant at($p<0.05$)

Effect of consumption on three levels of balsamic vinegar solution on biomarkers for liver enzymes in obese rats

The data presented in table (3) showed that aspartate aminotransferases (AST), alanine aminotransferases (ALT) and alkaline phosphatase (ALP) increased significantly at ($p<0.05$) in the control positive group recording values; 82.4 ± 7.2, 48.4± 3.6 and 230.4±11.9 respectively, as compared with control negative group recording values; 50.8 ± 6.5, 23.2±2.5 and 148.6±8.2 respectively.

The statistical analysis reflected that there were significant differences between all groups in Liver function, except for the group(5) and the negative control, no significant differences exist between them in ALP.

Likewise, the obtained results indicated that Liver function levels lower significantly at ($p<0.05$) for all treated groups (3,4 and 5) compared with positive group (2) (untreated group fed on high-fat diet) .

These results agree with **Soltan and Shehata .,(2012)** who reported that apple vinegar and grape vinegar decreased AST, ALT, urea and creatinine.

The levels of TC, TG, FFA, AST, ALT, and malondialdehyde (MDA) in HFD-induced rats were significantly decreased by aromatic vinegar **(Zhu *et al.*, 2020)**

Table (3): Effect of consumption on three levels of balsamic vinegar solution on biomarkers for liver enzymes in obese rats

Rats group	ALT (GPT) (U/L)	AST (GOT) (U/L)	ALP (U/L)
	Mean (±)SD	Mean (±)SD	Mean (±)SD
Group (1)	23.2^{d}±2.5	50.8^{c}±6.5	148.6^{e}±8.2
Group (2)	48.4^{a}± 3.6	82.4^{a}±7.2	230.4^{a}±11.9
Group (3)	35.2^{b}±3.2	65.2^{b}±4.1	200.8^{b}±6.9
Group (4)	33.6^{b}±4.4	58.0^{b}±6.3	185.0^{c}±5.4
Group (5)	28.6^{c}±1.9	53.4^{c}±3.2	170.4^{d}±4.2

Effect of consumption on three levels of balsamic vinegar solution on kidney functions in obese rats

The data illustrated in Table (4) revealed that Kidneys function levels of experimental rats showed significant differences among all groups, except for the group(5) (fed on high-fat diet plus 3% of balsamic vinegar solution) and the negative control, no significant differences exist between them.

On the other hand, significant increase observed in serum of urea, creatinine and uric acid at ($p<0.05$) for control positive group as compared with control negative

group. Likewise, the results obtained indicated that serum urea, creatinine and uric acid gradually decreased significantly at ($p < 0.05$) for all treated groups (3,4 and 5) compared to the positive group (2) ((untreated group fed on high-fat diet), recording;(27.2±1.3 , 26.4±2.4 , 22.8±3.2 and 32.7±3.4 mg/dl respectively.) for serum urea ,(0.78±0.13 , 0.68±0.08 , 0.56±0.11 and 1.00±0.23 mg/dl respectively) for creatinine and(2.4±0.60 , 2.2±0.56 , 1.7±0.18 and 2.9±0.47 mg/dl respectively) for uric acid. These results agree with **Soltan and Shehata, (2012)** showed that Apple vinegar and grape vinegar decreased AST, ALT, urea and creatinine.

Table (4): Effect of consumption on three levels of balsamic vinegar solution on kidney functions in obese rats

Rats group	Urea (mg/dl)	Creatinene (mg/dl)	Uric acid (mg/dl)
	Mean (±)SD	Mean (±)SD	Mean (±)SD
Group (1)	23.8^{c}± 2.2	0.59^{c}±0.13	1.6^{c}±0.46
Group (2)	32.7^{a}±3.4	1.00^{a}±0.23	2.9^{a}±0.47
Group (3)	27.2^{b}±1.3	0.78^{b}±0.13	2.4^{b}±0.60
Group (4)	26.4^{b}±2.4	0.68^{b}±0.08	2.2^{b}±0.56
Group (5)	22.8^{c}±3.2	0.56^{c}±0.11	1.7^{c}±0.18

CONCLUSION

Generally, according to the current study balsamic vinegar has high content of health and nutritional value. It may be useful for treating obesity, balsamic vinegar can be used to as anti-hyperlipidemia, and an anti- oxidative damage, anti-hepatic and kidney damage.

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تأثير التغذية بخل البلسميك علي الفئران المصابة بالسمنة

أماني أحمد عبد العزيز [1] إبراهيم محمد عبد الرازق[1]
أسامة السيد مصطفى[2] رقية محسن سرحان [1]
1قسم الاقتصاد المنزلي – كلية التربية النوعية – جامعة جنوب الوادي – مصر
2 كلية التربية النوعية، قسم الاقتصاد المنزلي، جامعة عين شمس ، مصر

الملخص

أجريت هذه الدراسة لمعرفة تأثير استهلاك تركيزات مختلفة من خل البلسميك على فئران التجارب المصابه بالسمنه 40 فار من ذكور ألبينو (متوسط وزن الجسم 160 جم) ، قسمت إلى 5 مجموعات (8 فئران / مجموعة). المجموعة (1): تغذت على النظام الغذائي الأساسي ، بينما تغذت المجموعات الأربعة على نظام غذائي عالي الدهون لمدة ستة أسابيع لأحداث السمنة. المجموعة (2) ، حُفظت كمجموعة ضابطة موجبة ، بينما عولجت فئران المجموعات (3 ، 4 ، 5) مستويات (75,. ، 1.5 ، 3٪) من محلول الخل البلسميك لمدة 6 أسابيع على التوالي. أظهرت النتائج أن استهلاك الخل البلسميك أدى إلى انخفاض وزن الجسم في جميع المجموعات المستهلكة لمحلول خل البلسميك مقارنة بالمجموعة(2) الضابطة الإيجابية. كما كان هناك انخفاض معنوي في مستوي الكوليسترول الكلي(.**CHO**) والدهون الثلاثية (**TG**) والليبوبروتينات منخفضه الكثافة(LDL) والليبوبروتينات منخفضه الكثافة جدا (VLDL) ، بينما كان هناك تزايد في مستوى الكوليسترول الدهني عالي الكثافة (HDL) في فئران والمجموعات الثلاثة المعالجة مقارنة المجموعة (2) الضابطة الإيجابية واظهرت الدراسة ايضا تحسن في كلا من وظائف الكلي وانزيمات الكبد في الفئران البدينة التي تناولت محلول الخل البلسميك. وخلصت الدراسة إلى أن الخل البلسمي ذو قيمه غذائية ممتازة ويحمي من السمنة

الكلمـــات المفتاحيـــة : خـل البلسـميك ، السـمنة ، دهـون الـدم، وظـائف الكبد، ، وظائف الكلى.