Effect of high-fructose corn syrup on some obesity markers in adult male rats

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تأثير شراب الذرة عالي الفركتوز على بعض مؤشرات السمنة في ذكور الجرذان البالغة

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المستخلص

يشكل شراب الذرة عالى الفركتوز ما يصل إلى 40 % من المحليات المستخدمة في جميع أنحاء العالم كمحليات صناعية بديلة عن السكر. وبما إن السمنة تزايدت بسرعة إلى مستويات وبائية في جميع أنحاء العالم وتلعب الهرمونات المشتقة من الأنسجة الدهنية دورا مركزيا في تنظيم الشهية، وتحقيق التوازن بين ما يأخذ من السعرات الحرارية وما يستهلك منها , لذا فقد أجريت التجرية الحالية لدراسة تأثير شراب الذرة عالى الفركتوز على مستويات هرمونات الادبونكتين اللبتين والرزستين تحليل الدهون في المصل وزن الجسم استهلاك الغذاء ونسبة الشحوم في منطقة البطن كمؤشرات للسمنة في ذكور الجرذان البالغة. قسم ثلاثون من ذكور الجرذان البالغة التي تزن 200-225 غرام وبعمر 12-15 أسبوع عشوائيا إلى خمسة مجموعات متساوية . أعطيت المجموعة الأولى (المجموعة أ) محلول 10٪ من شراب الذرة، أعطيت المجموعة الثانية (المجموعة ب) محلول 20٪ من شراب الذرة، والمجموعة الثالثة (المجموعة ج) أعطيت محلول 10٪ من السكروز، أعطيت المجموعة الرابعة (المجموعة د) محلول 20٪ من السكروز، وأعطيت المجموعة الخامسة (المجموعة هـ) الماء المقطر لمدة ثلاثين يوما. تم تغذيبة كل المجموعات بغذاء الجرذان القياسي والمحاليل حسب الحاجة. في نهاية التجربة تم وزن الحيوانات , والتضحية بها , جمعت العينات الدموية بواسطة ثقب القلب. كان هنالك زيادة معنوية (p < 0.05) في وزن الجسم، و نسبة الشحوم في البطن و TC, TAG, LDL-c, and VLDL-c , هرمون اللبتين وهرمون الرزستين في المصل في المجموعة ب مقارنتا مع جميع مجاميع التجربة . كان هنالك زيادة معنوية (p < 0.05) في وزن الجسم، و نسبة الشحوم في البطن وTC, TAG, LDL-c, and VLDL-c , هرمون اللبتين , هرمون الادبونكتين , وهرمون الرزستين في المصل في المجموعات أ جج , د مقارنتا مع المجوعة ه. في حين لم تكن هناك فروق معنوية بين المجموعات أججد في جميع المعايير المدروسة عند مقارنتها مع بعضها البعض انخفض ال HDL-C و هرمون الاديبونيكتين في مصل معنويا في المجموعات أ، ب، ج ، د بالمقارنة مع مجموعة ه. لم تكن هناك فروق معنوية في HDL-C وهرمون الاديبونيكتين في مجموعات أ، ب، ج، د بالمقارنة مع بعضها البعض يستنتج من ذلك أن الاستهلاك المفرط لشراب الذرة عالى الفركتوز قد يساهم في حدوث السمنة وكميات غير طبيعية من الدهون .

الكلمات المفتاحية: شراب الذرة عالى الفركتوز , مؤشرات السمنة , ذكور الجرذان

Abstract

High-fructose corn syrup (HFCS) accounts for as much as 40% of sweeteners used over all the world as an industrial sweetener - a substitute for sugar. As obesity has increase rapidly to epidemic proportions around the world, adipose derived hormone play central role in regulation of appetite , balancing between calorie input and calorie expenditure , so the current experiment conducted to investigate the effect of HFCS on serum adiponectin , leptin , resistin hormone levels

, lipid profile, body weights, food intake, and relative abdominal fat as obesity markers in adult male rats . Thirty adult male rats weighing 200 -225 gram and 12 - 15 weeks old were randomly divided in to five equal groups. The first group (Groups A) was given a 10% solution of HFCS, the second group (Groups B) was given a 20% solution of HFCS, the third group (group C) was given a 10% solution of sucrose, the fourth group (group D) was given a 20% solution of sucrose, the fifth group (group E) was given a distilled water for thirty days. All groups were fed with standard rat diet and their solutions ad libitum. At the end of experiment the animals were weighted, sacrificed, blood samples were collected by heart puncture. There were a significant increase ($p \le 0.05$) in body weights, relative abdominal fat, serum TC, TAG, LDL-c, and VLDL-c, leptin hormone, and resistin hormone in group B compared with all groups of experiment. There were a significant increase in body weights, relative abdominal fat, serum TC , TAG, LDL-c, and VLDL-c, leptin hormone, and resistin hormone in groups A, C and D compared with group E ,whereas there were no significant differences between group A and groups C, D in all studied parameters when compared with each other's. Serum HDL-c and adiponectin hormone decreased in groups A, B, C, D when compared with group E. There were no significant differences in HDL-c and adiponectin hormone in groups A, B, C, and D when compared with each other's. In Conclusions excessive consumption of HFCS may contribute to the incidence obesity and dyslipidemia.

Key words: high-fructose corn syrup, obesity markers, male rats.

Introduction

Obesity is one of the major health problems around the world that lead to heart diseases, hypertension and diabetes. Excessive caloric intake has been related to high-fat diets and foods high in sugars such as sucrose (1-2). HFCS were developed during the past three decades as sweeteners produced from cornstarch by isomerizing most of the glucose in corn syrup to fructose. Sucrose is made up of 50% glucose and 50% fructose, whereas HFCS in most foods and beverages are composed of 55% fructose and 45% glucose (in beverages) or 42% fructose and 58% glucose (in baked goods) (3). The isomerization of these sugars inexpensive this made it useful to replace sucrose (sugar) and they now represent close to one-half of the caloric sweeteners (4). Paralleled the huge increase in the consumption of sugars with

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obesity metabolic prevalence of and syndrome, kidney disease, and cardiovascular disease suggesting a causal relationship between the two, and though the extent of the contribution of monosugars in the epidemic compared to the total heat consumption remains a matter of dispute (5). Decreased circulating adiponectin concentration has been associated with several disorders like obesity, dyslipidemia, insulin resistance, type 2 diabetes, essential hypertension, and cardiovascular diseases (6). The plasma level of leptin and its expression in adipocytes are both correlated positively with total adiposity. Increased visceral fat has been associated with increase cytokines production and development of insulin resistance (7). Resistin hormone is also enhancing insulin resistance; interfere with adipocyte differentiation (8-9). Depending on the above the aims of the present study are to investigate the effects of HFCS on some obesity markers and make a comparison between the effects of HFCS and the effects of sucrose on these markers in male rats.

Materials and methods

Chemical

Commercial high fructose corn syrup manufactured by National Company for Maize Products ,Egypt was used in the present study.

Animals and experimental design

Thirty adult male rats weighing about 200-225 grams and 12 - 15 weeks old were used in the current study. Animals were kept under normal temperature (23 - 25 °C), and controlled lightening. Animals were randomly divided into five equal groups each group consisted of 6 adult male rats as in the following:-

- 1- Group A : was given a 10% solution of HFCS
- 2- Group B : was given a 20% solution of HFCS
- 3- Group C : was given a 10% solution of sucrose
- 4- Group D : was given a 20% solution of sucrose
- 5- Group E: was given distilled water. All. groups were fed with standard rat diet and their solutions ad libitum .

Animals were weighted at the beginning of the experiment and at the end of experiment, then animals were sacrificed and blood samples were collected by heart puncture, serum was separated, frozen at -20 until used.

Laboratory analysis

Serum Total Cholesterol (TC), Triglyceride (TAG), High Density Lipoprotein cholesterol

(HDL-c) were estimated by enzymatic colorimetric method using spectrophotometer by use liquicolor kits manufactured by biomaghreb company (Tunisia).

The serum Low density Lipoprotein cholesterol (LDL-c), very low density lipoprotein (VLDL-c) were calculated according to Friedewald *et al* (10):-

LDL = Total cholesterol (TC) - HDL - TG/5 (mg/dL).

VLDL-C = TAG / 5 (mg/dL).

Serum Adiponectin ,Leptin and resistin hormones levels were determined using enzyme linked immunosorbent assay (ELISA) kits manufactured by GenWay BIOTECH INC. (USA).

Statistical Analysis

Data were expressed as mean \pm SD. The comparisons between groups were performed with analysis of variance (ANOVA) by using computerized SPSS program (Statistical Program for Social Sciences). P<0.05 was considered to be the lest limit of significance.

Results

Effects of HFCS on body weight gain

The results in table (1) showed that there was a significant increase ($p \le 0.05$) in final body weights of animals in group B compared with final weight of animals in all groups of experiment. There were a significant increase ($p \le 0.05$) in final body weight of groups A,B,C, and D compared to the final weight of animals in group E, whereas there were no significant differences ($p \ge 0.05$) between groups A, C, and D when compared with each other's. Relative abdominal fat increased significantly ($p \le 0.05$) in group B compared with all other groups of the study. There were a significant increase in relative abdominal fat in groups A , B, C, and D when

compared with control group (group E) .No significant differences were noticed in groups A , C, and D when compared with each other's.

Table (1) Effect of high fructose corn syrup on male rats body weights and relative abdom	ninal
fat	

parameters	Initial body weight	Final body weight	Relative abdominal fat
Groups	(gram)	(gram)	(g/100 g B.W.)
Group A	210.12 ± 7.9	233.33±5.60	2.94±0.33
	A	b	b
Group B	214.16±7.75	243.00±5.09	4.95±0.75
	A	a	a
Group C	206.00±12.39	235.33±3.50	3.32±0.29
	A	b	b
Group D	212.33± 11.34	232.16±1.66	3.25±0.29
	A	b	b
Group E	210.16±6.24	215.33±7.91	1.86±0.31
	A	c	c

Numbers represent the mean ± Standard Deviation .

Different letters indicated significant differences between groups at level p<0.05

Effects of HFCS on lipids profile

The results presented in table (2) revealed that the high concentration of HFCS in group B caused significant ($p \le 0.05$) increase in serum TC , TAG , LDL-c and VLDL-c compared with groups A, C, D ,and E , also there were a significant ($p \le 0.05$) increase in serum TC , TAG , LDL-c , and VLDL-c in groups A, C, and D compared with group E , whereas there were no significant differences

in serum TC , TAG , LDL-c , and VLDL-c in groups A ,C ,and D when compared with each other .

As shown in table (2) serum HDL-c decreased significantly in groups A, B, C, and D compared with group E. There were no significant differences in serum HDL-c concentration in groups A, ,B,C, and D when compared with each other.

parameters	TC	HDL-c	TAG	LDL-c	VLDL-c
Groups	mg / dL	mg / dL	mg / dL	mg / dL	mg / dL
Group A	150.16 ± 9.98 b	41.50 ± 3.61 b	77.50 ± 3.08 b	46.83 ± 2.92 b	$\begin{array}{c} 22.83 \pm 4.07 \\ b \end{array}$
Group B	169.67 ± 17.23	39.33 ± 2.58	88.33 ± 4.96	59.83 ± 6.67	31.33 ±1.86
	a	B	a	a	a
Group C	140.33 ± 8.35 b	46.00 ± 3.22 b	74.00 ± 3.28 b	50.16 ± 6.85 b	$\begin{array}{c} 25.58 \pm 3.74 \\ b \end{array}$
Group D	148.67 ± 15.81	39.67 ± 5.78	80.50 ± 5.43	52.00 ± 5.93	27.29 ± 2.77
	b	B	B	b	b
Group E	119.67 ± 7.81	56.83 ± 9.28	67.67 ± 7.03	38.16 ± 1.47	17.16 ± 1.37
	c	A	C	c	c

Table (2) Effect of high fructose corn syrup on male rats' serum lipids profile

Numbers represent the mean \pm Standard Deviation .

Different letters indicated significant differences between groups at level p<0.05

Effects of HFCS on Adiponectin , Leptin , and resistin hormones .

It seems from table (3) that serum adiponectin hormone concentrations decreased significantly ($p \le 0.05$) in groups A, B, C, and D compared with group E, meanwhile on significant differences in serum adiponectin in groups A, B, C, and D when compared with each other's.

Serum leptin and resistin hormones concentrations increased significantly ($p \le 0.05$) in animals treated with high concentration of HFCS (group B) compared with all groups of the study, whereas there were a significant increase in serum leptin and resistin hormone in groups A, C, and D compared with group E. There were no significant differences between groups A, C, and D when compared with each other's.

Hormone	Adiponectin	Leptin	Resistin
Groups	(pg/ml)	(pg/ml)	(pg/ml)
Group A	2.01 ± 0.08	12.97 ± 3.34	3.37 ± 0.99
	b	b	b
Group B	1.84± 0.83	17.96 ± 1.90	5.63 ± 1.48
	b	a	a
Group C	2.17 ± 0.25	13.76 ± 0.94	3.25 ± 0.67
	b	b	b
Group D	2.12 ± 0.29	15.14 ± 2.27	3.79 ± 0.53
	b	b	b
Group E	2.90 ± 0.57	6.69 ± 2.22	2.09 ± 0.50
	a	c	c

 Table (3): Effect of high fructose corn syrup on some adipose – derived hormones in male

Numbers represent the mean ± Standard Deviation .

Different letters indicated significant differences between groups at level p<0.05

Discussion

The significant increase in final body weights in rats exposed to 20% HFCS concentrations (Table 1) may be due to that fructose bypasses many of the body's satiating signals, thus potentially promoting overconsumption of energy, weight gain (11). Another reason is that the increased body weight paralleled with increased leptin hormone concentration, which may reflect leptin resistance .According to Engl (12) increased serum leptin concentrations in obese subjects, suggests a decreased sensitivity or resistance to leptin. The results of the current study came in agreement with Bocarslya et al. (13) who reported that short and long term effects of HFCS can cause increase boy weight and serum triglycerides .The significant decrease in serum adiponectin shown by the present study could be considered as another reason for the increased body weight, and abdominal fat based on the known role of adiponectin in increased lipid metabolism, fatty acid oxidation in skeletal muscle (14). It seem

from the results of lipid profile showed in table (2) that serum TC, TAG LDL-C and VLDL-c increased significantly in animals exposed to 20% HFCS compared with other groups, the possible explanations may be due to increased serum leptin which correlated positively with serum cholesterol, LDL-c, triglyceride and consequently VLDL-c whereas it correlated negatively with HDL-c (15). The decreased serum level of adiponectin in HFCS exposed rats can also explain the results of lipid profile , according to Izadi et al. (16) who reported that serum adiponectin inversely correlated with VLDL-C and LDL-c and triglycerides and directly correlated with serum HDL-c .Another study suggested that high fructose diet deceases the high molecular weight adiponectin (17) The rise in resistin hormone can considered as an important sign of obesity (18). The results of the current study disagreed with Pollock et al. (19) who reported that no relations between total fructose intake and plasma total cholesterol, serum leptin, and plasma resistin. We can conclude from the present study that HFCS can induce obesity and risks of excessive HFCS more than that caused by sucrose consumption.

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