Effect of Monosaccharide Rich Diets on Blood Lipid Profile of Rats.

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ABSTRACT

The objective of this study was to investigate the effect of six types of monosaccharide feeding regimen on blood lipid profile and recommend the best monosaccharide of moderate effect on growth rate and changes in blood lipid profile. Thirty five male albino rats (sprague dawlley) were segregated into 7 groups. The first served as normal control. The second received 10% glucose diet, the third received 10% fructose diet, the forth received 20% glucose diet, the fifth received 20% fructose diet, the sixth received 5% glucose plus 5% fructose fed diet, the seventh received 10% glucose plus 10% fructose diet. Samples were taken after 3 weeks of feeding. Body weights, organs weights and blood lipid profile were recorded. The relative growth rate was enhanced with fructose feeding than others. This enhancement is moderate for 10% fructose feeding. The relative organs weights were better in 10% fructose fed group than other groups. 10 % fructose fed diet showed lowest elevation lipid fractions than other groups.

These findings clearly indicate that 10% fructose fed diet is the best choice for its moderate enhancement of relative growth rate and its lowest effect on serum lipid profile and so can be recommended for use in sweets production.

***Key words*: glucose; fructose; rats; lipids; body weights.**

INTRODUCTION:

Added sugars represent more than 30% of carbohydrate consumption (Popkin and Nielsen, 2003). Studies showed that a small amount of fructose in the presence of high levels of glucose increased the net hepatic glucose uptake and the glycogen synthesis (Shiota *et al.*, 1998 and 2002 and McGuinness and Cherrington, 2003). It was reported that high carbohydrate diet induced elevations in both serum and liver lipids, including cholesterol, triglycerides, phospholipids and total lipids (Shalan, 1996).

Fructose feeding has been shown to induce hypertriglyceridemia, hyperinsulinemia, and hyperglycemia (Raiamani *et al.*, 2005). High fructose (21%) feeding induced diabetes in rats (Yadav *et al.*, 2006). Metabolism of dietary fructose differs from that of glucose. Hepatic glucose metabolism is acutely regulated by phosphofuctokinase 1, a key regulatory step of glycolysis. In contrast, fructose enters the glycolytic pathway at the triose level, bypassing phsphofructokinase 1. This difference in intial metabolism of fructose not only acutely affects carbohydrate metabolism by changing supply of intermediate metabolites, but also induces metabolic adaptation including changes in gene expression (Koo *et al.*, 2008). Most Egyptian sweet producers use glucose in their products.

Therefore, the objective of the present study was to determine the best monosaccharide percentage composition in the diet that has little effect on blood lipid profile to be recommended for use in sweet production.

MATERIAL AND METHODS:

Animals:

Thirty five male albino rats(sprague dawlley stran) 6 weeks old, purchased from the Egyptian Organization for immunity and Vaccine giza , Egypt, were randomly housed in plastic cages. Animals were housed in a controlled-temperature (25 ± 2 °C) and

humidity (25 ± 2 %) environment, with a 12 hours light / dark cycle and free access to food and tap water. Body weight and food intake were determined at week intervals for 3 weeks of experiment.

Diets preparation:

Basal balanced diet:

Basal diet prepared form fine ingredients per 100g according to AIN (1993). The diet composed of 14% protein (derived from neutral casein); sunflower oil 10%; salt mixture 4% (hegested etal.,1941); vitamin mixture 1% (camphell1961); Dl-methionine 0.3%, choline chloride 0.2% and corn starch up to 100g.

Experimental design:

Animals were segregated into 7 groups:

1- Control group: A group of animals offered Basal balanced diet and tap water *ad-libitum*.
2- 10% glucose group: Rats received the same diet but containing 10% at expens of starch glucose and tap water *ad-libitum*.
3- 10% fructose group: This group received 10% at expens of starch fructose diet and tap water *ad-libitum*.
4- 20% glucose group: A group of animals fed 20% at expens of starch glucose diet and tap water *ad-libitum*.
5- 20% fructose group: Rats received 20% at expens of starch fructose diet and tap water *ad-libitum*.
6- 5% glucose plus 5% fructose group: This group received a diet containing 5% glucose plus 5% fructose at expens of starch and tap water *ad-libitum*.
7- 10% glucose plus 10% fructose group: In this group rats received a diet containing 10% glucose plus 10% fructose at expens of starch and tap water *ad-libitum*.

At the end of experiment all groups of animal were anaesthetized with diethyl ether and Blood samples were collected from the inferior vena cova in glass centrifuge tubes. then centrifuge for 15 min at 1000 x g. Sera were separated and stored at –20 °C in deep freezer till further biochemical analysis

Biochemical analysis:

Serum triglycerides were determined using kits, Germany, utilizing the method of Shephared and Whiting (1990). Serum cholesterol was measured by the method of Allain *et al.*, (1974) using Human kits, Germany. Serum total lipids were measured according to the method of Knight *et al.*, (1972) using Bio Adwic kits, Egypt. Serum high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C) were estimated by the method of fridewald W.T1972

Relative growth rate:

The relative growth rate of rats was calculated using the following formula:

$(W1-W0)/W0 \times 100\%$.

Where:

W0: The mean body weight at the experimental beginning.

W1: The mean body weight at the experimental final.

Statistical analysis:

Values were statistically analyzed by one-way analysis of variance (Anova-Tukey test) using SPSS 10.1 software package. The P values <0.05 were considered significant.

Results

The results showed that relative growth rate (RGR) is more enhanced with 10% and 20% fructose feeding than other groups. This enhancement (after 3 wk.) amounted to 14.56% and 17.35 % respectively compared to normal control (Table 4). The relative hepatic weight (Table 6) was significantly reduced only in 10% glucose feeding group amounted to 20.57% compared with normal control. On the other hand relative kidney weight was decreased significantly in 10, 20% glucose and 20% fructose feeding decrease groups amounted to 23.73,

27.12 and 18.64% respectively compared with normal control.

Results of table (5) indicated that spleen/body weight ratio was decreased significantly in 10, 20% glucose, 20% fructose and 5% glucose + 5% fructose diet groups in comparison with normal control, with magnitudes of 20.5, 28.21, 28.21 and 25.64% respectively. The relative heart weight was decreased significantly by 20.69% in 20% glucose diet group compared with normal control (Table 6).

Serum total lipids tended to be of higher level in 10% glucose + 10% fructose group, however the lowest level was recorded in 10% fructose diet group compared with normal control. Total cholesterol and triglycerides were elevated in 10% glucose + 10% fructose fed group than normal control with ratios of 27.39 and 76.07% respectively. The lowest levels compared with normal control for the two parameters were recorded in 10% fructose fed group (Table 7).

LDL cholesterol tended to be of higher level in 20% glucose fed group with magnitude of 170.62% compared with normal control, however the lowest level was recorded in 20% fructose fed group with the ratio of 68.99% compared with normal control. Finally, HDL cholesterol tended to be of lower level in 10% fructose diet group by 35.73% compared with normal control. HDL Cholesterol was approximately not affected in 10% glucose + 10% fructose fed group.

It could be noticed that monosaccharides feeding approximately not affected the food consumption of rats significantly (Table 8).

Discussion:

Table(4) results represents the relative growth rate for the various study groups. The results indicated that fructose fed groups enhanced relative growth rate than other groups. Decreased food intake (Table 8) may be responsible for the difference in weight gain rather than a decrease in utilization of the diet. Liver weights were not significantly different among the groups, however significant difference ($P< 0.05$) for lower relative liver weights for the 10% glucose fed group recorded in (Table 6) comparison with normal control.these observation due to fructose feeding increases liver weight due to excess of fat accumulation (Poulsom 1986). Kidney, spleen and heart relative weights (Table 6) were decreased in glucose feeding than in fructose feeding but, more oriented with glucose + fructose diet. The liver is the most important organ for regulating glucose metabolism by assimilating increased blood glucose level in the form of glycogen and/or regulating the new synthesis of glucose through gluconeogenesis (Yoon *et al.*, 2001). The liver plays the major role in fructose metabolism (Koo *et al.*, 2008). Fructose enters glycolysis or gluconeogenesis at triphosphate level, bypassing the need for insulin and the action of phosphofructokinase.

After fructokinase catalyzes phosphorylation of fructose to fructose 1-phosphate, the resulting compound is split by hepatic aldolase B into glyceraldehydes and dihydroxyacetone phosphate. The activities of fuctokinase and hepatic aldolase B are increased when the amount of fructose in the diet increased leading to enhanced hepatic lipogenesis (Reiser and Hallfrisch, 1987).

Varying the type of dietary carbohydrate could cause changes in the metabolism of lipids. Michaelis *et al.*, (1975) described an increase in total liver lipids in rats when glucose was isocalorically substituted with either sucrose or fructose. This effect was attributed to the induction of various lipogenic enzymes in liver by fructose (Anitha Nandhini *et al.*, 2002). The results showed that 10% fructose feeding induced lower effect on blood lipids and that glucose feeding elevated serum triglycerides concentration than fructose feeding and mixing both in diet elevated more triglyceride levels. Our results were in agreement with those reported by Hallfrisch *et al.*, (1983). Who reported that fructose feeding may lead to hypertriglyceridemia by

increasing the formation of glycerol-3-phosphate, a precursor of lipid synthesis (Zavaroni *et al.*, 1980). Adverse effects of glucose and fructose feeding on serum cholesterol have been previously reported in rats (Fields *et al.*, 1996 and Lingelbach and McDonald, 2000). Hypertriglyceridemia may be due to a defect in removal of VLDL from plasma or increased secretion of VLDL. Anitha Nandhini *et al.*, (2002) showed a significant reduction in the activity of lipoprotein lipase which can cause hypertriglyceridemia and accumulation of VLDL in plasma of the fructose fed rats.

The results indicated decreased serum HDL cholesterol concentration in both glucose and fructose groups and approached normal in 10% glucose + 10% fructose fed group. Anitha Nandhini *et al.*, (2002) attributed the lowered HDL cholesterol concentration in fructose fed rats to the decreased lipoprotein lipase (LPL) and lecithin cholesterol acyl transferase (LCAT) activities in plasma and in the liver, where LCAT catalyses esterification of cholesterol with fatty acids, along with LPL which is responsible for HDL cholesterol synthesis and plays an important role in cholesterol and triglyceride transport and metabolism. Results showed increased LDL cholesterol concentrations in all groups especially in glucose fed groups. It was shown that extra sugars may produce high levels of LDL cholesterol that may contribute to the induction of diabetic dislipidemia (Mayers, 1993).

Esterbauer *et al.*,(1992) showed that fructose feeding enhanced plasma vitamin E depletion which predispose VLDL and LDL enriched with triacylglycerol to subsequent oxidative stress, which is one of the critical mechanisms involved in the progression of atherosclerosis (Girard *et al.*, 2005).

Conclusion:

It could be noticed that 10% fructose feeding enhanced the lowest elevation in serum lipid profile accompanied by moderate enhancement in relative growth rate and organs weights. From this view, it is assumed to be the better choice for using in sweet production instead of other percentages of glucose and fructose.

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Table (3): Body weights (in gram) of rats fed varying levels of dietary glucose and fructose.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
0 time	151.5 ± 8.8	191.6 [a] ± 16.04	179.8 [a] ± 11.14	185.8 [a] ± 14.39	186 [a] ±14.75	186.2 [a] ± 25.26	180.6 [a] ± 18.32
1 week	178.5 ± 18.89	219 [a] ± 12.59	207.2 ± 8.76	203.8 ± 25.59	214 [a] ± 13.62	206.4 ± 23.84	200 ± 14.97
2 weeks	202.3 ± 23.30	247.2 [a] ± 14.38	238.8 [a] ± 23.29	232 ± 25.99	247 [a] ± 18.63	223.6 ± 37.92	225.8 ± 21.9
3 weeks	215.5 ± 26.07	270 [a] ± 17.71	266.8 [a] ± 26.75	272.5 [a] ± 10.7	278.2 [a] ± 28.55	261.8 [a] ± 29.89	249.2 ± 22.91

Table (4): Effect of varying levels of monosaccharides on relative growth rate of rats.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
1 week	17.82 ± 1.71	[a,d,f,g] 14.3 ± 1.52	[d,f,g] 15.24 ± 1.44	[a,b,c,e] 9.69 ± 0.91	[a,f,g] 15.05 ± 1.61	[b,c,e] 10.85 ± 1.11	[a,b,c,e] 10.74 ± 1.18
2 weeks	33.53 ± 3.43	29.02 ± 3.12	[d,g] 32.81 ± 3.14	[a,c,e,f] 24.87 ± 2.61	[d,g] 32.79 ± 3.32	[a,d,g] 30.09 ± 1.96	[a,c,e,f] 25.03 ± 2.66
3 weeks	42.24. ± 4.16	40.92 ± 4.18	[b,f,g] 48.39 ± 5.12	[g] 46.66 ± 4.73	[b,f,g] 49.57 ± 5.52	[e] 40.6 ±3.37	[c,d,e] 37.98 ± 4.16

Table (5): Effect of glucose and fructose feeding for 3 weeks on liver, kidney, spleen and heart weights (in gram) of rats.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
Liver	6.07 ± 0.72	6.06 ± 1.23	6.58 ± 1.07	6.37 ± 1.05	6.80 ±1.13	6.42 ± 0.41	5.87 ± 0.72
Kidney	1.27 ± 0.18	1.22 ± 0.22	1.35 ± 0.19	1.17 ± 0.12	1.34 ± 0.13	1.33 ± 0.14	1.25 ± 0.17
Spleen	0.84 ± 0.20	0.83 ± 0.18	0.90 ± 0.15	0.77 ± 0.10	0.78 ± 0.09	0.77 ± 0.05	[d,f] 1.91 ± 0.10
Heart	0.64 ± 0.07	[d] 0.75 ± 0.11	[a,d] 0.78 ± 0.10	[c,e] 0.63 ± 0.07	[a,d] 0.81 ± 0.09	0.70 ± 0.10	0.73 ± 0.08

Table (6): Effect of glucose and fructose feeding for 3 weeks on relative organs weights (organ weight (g)/body weight (g) X 100) of rats.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
Liver	2.82 ± 0.23	[a] 2.24 ± 0.24	2.46 ± 0.25	2.34 ± 0.24	2.44 ±0.26	2.46 ± 0.27	2.36 ± 0.22
Kidney	0.59 ± 0.08	[a] 0.45 ± 0.05	[d] 0.51 ± 0.06	[a] 0.43 ± 0.04	[a] 0.48 ± 0.05	[d] 0.51 ± 0.05	0.50 ± 0.04
Spleen	0.39 ± 0.04	[a] 0.31 ± 0.03	[d,e] 0.34 ± 0.04	[a,g] 0.28 ± 0.03	[a,g] 0.28 ± 0.02	[a,g] 0.29 ± 0.03	[b,d,e,f] 0.37 ± 0.04
Heart	0.29 ± 0.03	[e] 0.28 ± 0.03	[d] 0.29 ± 0.03	[a,c,e,g] 0.23 ± 0.03	[d] 0.29 ± 0.03	0.27 ± 0.03	[d] 0.29 ± 0.03

Table (7): Effect of varying levels of monosaccharides on serum lipid profile of rats.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
Total cholesterol (mg/dl)	66.48 ± 7.81	[a,c] 78.98 ± 8.45	[d,g] 66.94 ± 5.48	[a,c,e] 83.76 ± 7.28	[d,g] 67.77 ±6.58	[a,c,e] 79.98 ± 11.45	[a,c,e] 84.69 ± 7.36
Triglycerides (mg/dl)	57.75 ± 4.30	[a,c] 85.04 ± 8.11	[a,d,f,g] 69.87 ± 8.52	[a,c,e] 97.66 ± 10.15	[a,d,f,g] 78.24 ± 9.31	[a,c,e] 98.4 ± 10.19	[a,b,c,e] 101.68 ± 8.04
HDL-C (mg/dl)	42.09 ± 4.25	[a,c,g] 32.53 ± 3.46	[a,d,g] 27.05 ± 2.53	[a,c] 34.51 ± 3.71	[a,g] 30.32 ± 4.11	[a,g] 30.05 ± 5.43	[b,c,e,f] 40.24 ± 6.13
LDL-C (mg/dl)	12.90 ± 1.12	[a,e,f,g] 29.44 ± 3.15	[a,d,e] 25.92 ± 2.74	[a,b,c,e,f,g] 34.91 ± 3.55	[a,b,d] 21.8 ± 2.22	[a,b,d] 22.25 ± 2.03	[a,b,d] 24.11 ± 2.36
Total lipids (mg/dl)	147.14 ± 15.2	[a,c] 220.64 ± 21.13	[a,d,f,g] 181.56 ± 20.63	[a,c,e] 257.21 ± 24.19	[a,d,f,g] 205.29 ± 20.12	[a,c,e] 251.5 ± 29.71	[a,b,e] 263.27 ± 17.44

Table (8): Effect of varying levels of monosaccharides on daily food intake (in gram) of rats.

	Control	10% glucose	10% fructose	20% glucose	20% fructose	5% glucose + 5% fructose	10% glucose + 10% fructose
0 time	61 ± 5.6	60 ± 6.04	61 ± 6.23	55 ± 5.66	58 ±5.64	61 ± 6.19	60 ± 5.9
1st week	63 ± 6.4	61 ± 6.15	62 ± 6.51	57 ± 6.11	62 ±6.21	63 ± 6.42	62 ± 6.51
2nd week	70 ± 7.2	68 ± 6.94	69 ± 7.17	64 ± 6.48	69 ± 6.13	68 ± 6.91	65 ± 6.67
3rd week	77 ± 7.4	75 ± 7.34	79 ± 8.23	75 ± 7.76	78 ± 6.9	75 ± 7.8	72 ± 7.41

تأثير الأغذية الغنية بأحاديات التسكر علي دهون الدم في الجرذان.

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الملخص العربي

الغرض من هذه الدراسة هو إيضاح تأثير ستة أنواع من الأغذية المحتوية علي نسب مختلفة من السكريات الاحادية على دهون الدم، و التوصية بأفضلها لاستخدامه في إنتاج الحلوي. قسم خمس وثلاثين من ذكور الجرذان البيضاء إلي سبعة مجموعات. استخدمت المجموعة الأولي كمجموعة ضابطة. أعطيت المجموعة الثانية وجبة غذائية تحتوي على ١٠%جلوكوز، أما المجموعة الثالثة فقد أعطيت غذاء يحتوي على ١٠% فراكتوز، بينما أعطيت المجموعة الرابعة غذاء يحتوي على ٢٠% جلوكوز. هذا وقد أعطيت المجموعة الخامسة غذاء يحتوي على ٢٠% فراكتوز، وأعطيت المجموعة السادسة غذاء يحتوي على ٥% جلوكوز بالإضافة إلي ٥% فراكتوز، أما المجموعة السابعة فقد أعطيت غذاء يحتوي على ١٠% جلوكوز، ١٠% فراكتوز.
هذا وقد تم أخذ العينات بعد ثلاثة أسابيع من بدء التغذية، تم تسجيل وزن الجسم والأعضاء، ودهون الدم. لوحظ أن الغذاء المحتوي على الفراكتوز قد حفز زيادة معدل النمو النسبي عن باقي المجموعات التجريبية، وقد كانت هذه الزيادة متوسطة مع التغذية على ١٠% فركتوز. هذا وقد كان وزن الأعضاء النسبي أفضل في المجموعة المغذاة ب ١٠% فركتوز عن باقي المجموعات التجريبية. كما لوحظ أن الغذاء المحتوي علي ١٠% فركتوز احدث اقل تأثير على دهون الدم.
تشير هذه النتائج بوضوح إلي أن الغذاء المحتوي على ١٠% فركتوز هو أفضل اختيار لتأثيره المتوسط على معدل النمو النسبي، ولتأثيره المنخفض علي دهون الدم، ولذلك يمكن التوصية به لاستخدامه في إنتاج الحلوى