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Possible effects of eating popcorn, and roasted corn on alloxan-induced diabetic rats

Olfat R. Khater, Amina M. Shalan

Department of Nutrition and Food Sciences, Faculty of Home Economics , Menoufia University, Shibin El Kom, Egypt

Abstract

This study aimed to evaluate the effect of eating popcorn, roasted corn, and their mixture on diabetic rats. In this study, 48 adult male albino rats weighing (150±10g) were divided into eight groups, each with six rats. Popcorn, roasted corn, and powdered mixtures were added to the main diet at a rate of 2.5 percent and 5% for 28 days. Alloxan (150 mg/kg body weight) was injected subcutaneously into diabetic rats. Serum lipid profiles [triglycerides (TG), total cholesterol (TC), low-density lipoprotein (LDL-c), very low-density lipoprotein (VLDL-c), high-density lipoprotein (HDL-c)], glucose levels, liver enzyme activities (ALT, AST, and ALP), and kidney functions (creatinine, uric acid, and urea levels) were measured at the end of the experiment. The results indicated that eating powder popcorn, roasted corn, or their mixture increased HDL-c significantly ($P \leq 0.05$) and improved kidney and liver functions by lowering ALT, AST, ALP, creatinine, uric acid, urea, and serum glucose.

Keywords: Cereals, Diabetic, Rats, and Biochemical analysis.

Introduction

Diabetes mellitus (DM) is the world's most common endocrine disease, and it has associated with a higher risk of morbidity and mortality. Diabetes mellitus is associated with retinopathy, nephropathy, neuropathy, and angiopathy, among other long-term complications [1]. It is usually appeared after several years (10 to 20 years). However, they may be the initial symptom in those who have not yet been diagnosed. Damage to blood arteries is the most severe long-term consequence. It doubles the risk of cardiovascular disease, and coronary artery disease is responsible for nearly 75% of diabetes deaths. Stroke and peripheral vascular disease are two other "macrovascular"

disorders [2]. A variety of pathologic processes brings it on. These include autoimmune destruction of the panaceas' b-cells, which causes insulin deficiency, and abnormalities that cause insulin resistance. Anomalies in glucose, lipid, and protein metabolism in diabetes are caused by a lack of insulin action on target tissues [3]. The loss of insulin-producing beta cells in the pancreas islets of Langerhans causes insulin insufficiency in type 1 diabetes mellitus. Idiopathic diabetes and immune-mediated diabetes are two types of diabetes. Most people with type 1 diabetes are treated with immunotherapy, which involves an autoimmune attack driven by T cells that causes beta cell death [4].

Diet therapy, especially, is showing a bright future in the therapy of DM. In particular, the commonly consumed cereal grains have been reported to possess antidiabetic properties. There are a variety of grains and grain products that can be beneficial in lowering glucose and insulin responses. The synergistic effect of several wholegrains and wholegrain components such as dietary fiber, phytochemicals, vitamin E, Mg, or others may reduce the risk for type 2 diabetes mellitus (T2DM) [5].

Maize, sometimes known as corn (*Zea mays, L*.), is a major annual grain crop that belongs to the Poaceae family. Mays is a Taino term that means "life provider." Zea is an old Greek word that means "supporting life." The word "maize" is derived from the Spanish word "maize," which is the most accurate plant description. The plant is also known by various names such as zea, silk maize, Makka, barajovar, etc. In many regions of the world, it is considered a staple food. After rice and wheat, it is the world's third most important crop [6]. Nutritionists often consider snack foods unhealthy due to their high fat and sugar content. While this is true of most snack foods, some can provide consumers with more than just a filler between meals. In some studies, snacking has been linked to better overall diet quality in adults and the consumption of whole grains. *Popcorn* is a popular food that is a healthy, whole grain alternative to potato chips and other snacks [7]. Because popcorn is a popular whole grain snack, Burgess-Champoux et al. [8] suggested that it could be a substantial potential source of phytochemicals in the American diet. Popcorn accounts for 17% of the total amount of whole grains consumed in the United States.

Compared to non-popcorn eaters, popcorn eaters ingest 250 percent more whole grains and 22 percent more fiber. *Popcorn* is a diverse and nutritious snack with benefits such as dietary fiber, protein, and B-complex vitamins [9]. Corn's antioxidant activity may be harmed by releasing additional phenolic compounds and the destruction or synthesis of redox-active metabolites after cooking [10]. According to Montonen et al. [11], there is an inverse relationship between wholegrain intake and the risk of type 2 diabetes. The wholegrain association could be attributable to cereal fiber or another factor connected to cereal fiber consumption, based on the results for cereal fiber intake. Other bioactive chemicals in wholegrain and wholegrain products, such as lignans, tocotrienols, phytic

acids, and other anti-nutrients, could also be to blame for the decrease. According to Rukmini [12], high amylose corn starch meals with or without roasted had a significant effect on serum blood glucose levels and body weight gain. High amylose corn starch created propionic, butyric acid at lower levels. In contrast, acetic acid was formed at the maximum level by roasted high amylose corn starch.

The objective of this study was to find out how varying levels of intake of popcorn, roasted corn, and their mixture as powder affected biological and some biochemical complications in diabetic rats.

Material and Methods

Materials

Source of popcorn and roasted corn

Popcorn and roasted corn (*Zea mays*, L.) were obtained from local market, at Sheben El-Kom City, Menoufia Governorate, Egypt.

Alloxan

Alloxan, also known as 5, 5-dihydroxyl pyrimidine-2, 4, 6-trione, is an organic molecule, urea derivative, carcinogen, and cytotoxic glucose derivative obtained by Al-Gomhoria Company for Trading Drugs, Chemicals, and Medical Instruments in Cairo, Egypt.

Experimental animals

Vaccine and Immunity Organization, Ministry of Health, Helwan Farm, Cairo, Egypt provided a total of 48 adult normal male albino rats "Sprague Dawley" strain weighing 150±10 g.

The chemicals and kits

SIGMA Chemical Co., Egypt, provided pure white crystalline cholesterol powder and saline solutions. Morgan Co. Cairo, Egypt provided casein, cellulose, choline chloride powder, and DL methionine powder. Al-Gomhoria Company for Trading Drugs, Chemical and Medical Instruments, Cairo, Egypt, provided the chemical kits (TC, TG, HDL-c, ALT, AST, ALP, urea, and creatinine) utilized in this examination.

Methods

Preparation of popcorn and roasted corn powdered

The popcorn and roasted corn were ground to a fine powder in an air mill, then mixed with a high-speed mixer (Molunix, Al-Araby firm, Benha, Egypt) and served as powder seize.

The induction of experimental diabetes:

According to Desai and Bhide [13] method, diabetes was induced in normal healthy male albino rats by injecting 150 mg/kg body weight of alloxan intraperitoneally.

Fasting blood samples were taken one week after alloxan injections to measure fasting serum glucose 200 mg/dL in diabetes rats NDDG, [14].

Experimental design:

The study was carried out and approved at Animal House, Department of Nutrition and Food Science, Faculty of Home Economics, Menoufia University, Egypt.

In this experiment, 48 adult male white albino rats, "Sprague Dawley" strain, 10 weeks old, weighing [150±10g), were used. For adaptation, all rats were fed a basal diet [casein diet) prepared according to Reeves, [15] for 7 days. After this adaptation period, rats were divided into 8 groups, six rats per each as follows: group (1): rats fed on basal diet only as negative control. Group (2): Diabetic rats fed on basal diet only as a positive control group. Group (3): Diabetic rats fed on basal diet and popcorn as powder by 2.5% of diet. Group (4): Diabetic rats fed on basal diet and popcorn as powder by 5% of diet Group (5): Diabetic rats fed on basal diet and roasted corn2.5% of diet. Group (6): Diabetic rats fed on basal diet and roasted corn 5% of diet. Group (7): Diabetic rats fed on basal diet and mixture (1:1) of popcorn and roasted corn2.5% of diet. Group (8): Diabetic rats fed on basal diet and mixture (1:1) of popcorn and roasted corn5% of diet. The experiment continued for 28 days, at the end of the experimental period each rat weight separately, then slaughtered and blood samples were collected.

Blood sampling

At the end of the experiment period (28 days), rats were fasted for 12-h then rats were scarified. Blood samples were collected from the portal vein into dry clean centrifuge tubes for serum separation, blood samples centrifuged for 10 minutes at 4000 rpm to separate, the serum according to Schermer [16]. Serum samples were frozen at -18 °C until chemical analysis.

Biochemical analysis

Serum glucose was measured using the modified kinetic method according to Kaplan, [17] by using kit supplied by spin react. Spain.

The serum alanine aminotransferase (ALT), serum asparatate aminotransferase (AST), and serum alkaline phosphatase (ALP) were measured using the methods described by Hafkenscheid [18]; Henry, [19] and Moss [20], respectively.

Serum total cholesterol was determined according to the colorimetric method described by Thomas [21]. Serum triglycerides was determined by enzymatic method using kits according to the Young [22] and Fossati & Pricipe, [23]. HDL-c was determined according to the method described by Friedwaid [24] and Grodon & Amer, [25]. VLDL-c and LDLc were calculated in mg/dL according to Lee and Nieman, [26] using the following formulas:

VLDL-c (mg/dL) = Triglycerides / 5.

LDL-c (mg/dL) = Total cholesterol – (HDL-c + VLDL-c).

According to the method, serum urea and serum creatinine were determined using an enzymatic technique Patton & crouch, [27] and Henry, [28]. While serum uric acid was measured using a calorimeter using the method of Barham and Trinder, [29].

Statistical analysis

The data were analyzed using a completely randomized factorial design SAS, (30] when a significant main effect was detected; the means were separated with the Student-Newman-Keuls Test. Differences between treatments of ($P \leq 0.05$) were considered significant using Costat Program. Biological results were analyzed by One Way ANOVA.

Results and Discussion

Table (1) shows the effect of popcorn, roasted corn, and their powdered mixture on glucose levels of diabetic rats. There are significant differences($P \leq 0.05$) between the negative control and positive control groups, with mean values of 105.00 and 297.50 mg/dL, respectively.

The diabetic group rats fed on a 5% mixture powder had the lowest glucose level of any of the treated groups (diabetic). While the maximum value observed for diabetes group rats fed 2.5 percent roasted corn powder. The mean values were 126.50 and 160.40 mg/dL, respectively, with a significant difference ($P \leq 0.05$). These findings are consistent with those of Yamini and Trumbo, [31] who concluded that consumption of whole grains is linked to a lower incidence of type 2 diabetes in various recent reviews and epidemiology studies. Whole grains contain dietary magnesium, fiber, and vitamin E, all of which aid in insulin metabolism.

Van Hung, [32], who reported that eating whole grains like popcorn can lower the risk of diabetes, heart disease, and hypertension due to it is contain many active compounds. It is critical, however, that the entire kernel be eaten. Despite accounting for only 15–20 percent of the overall weight of the popcorn kernel, the pericarp contains around 98 percent of the phenolic and antioxidant content.

Regular ingestion of several compounds found in whole grains, according to Slavin, [33], may help manage insulin levels. Furthermore, complete grains like maize and its derivatives (popcorn and roasted corn) may help manage insulin levels by releasing satiety and lowering body mass index (BMI).

The effect of popcorn, roasted corn, and their mixed powders on diabetic rats' liver functions (ALT, AST, and ALP) is shown in Table (2).

The data showed that positive control groups had higher values ($P \leq 0.05$) of ALT, AST and ALP than negative control and treated groups. This evidence agrees with the findings Marchesini *et al.* [34], who showed that the enzyme level of transaminases elevated in diabetic rats.

Table (1): Effect of consumption different levels of popcorn, roasted corn, and their mixture on serum glucose level of diabetic rats

	Glucose level (mg/dL)
Control group (-)	105.00f± 0.40
Control group (+)	297.50 a± 1.10
G3 (2.5% popcorn)	151.00c± 0.10
G4 (5% popcorn)	139.50d± 0.30
G5(2.5% roasted corn)	160.40 b± 0.30
G6(5% roasted corn)	149.50 c± 0.20
G7 (2.5% mixture)	136.00d± 0.10
G8 (5%mixture)	126.50e± 0.20
LSD (P≤0.05)	4.150

Each value represents the mean ± SD of six replicates. Means in the same column with different letter are significantly different (P<0.05).

Table (2): Effect of consumption different levels of popcorn, roasted corn, and their mixture powders, on some liver functions level of diabetic rats

	ALT (U/L)	AST (U/L)	ALP (U/L)
G1 C (-)	96.50h ±1.10	10.65g ±1.12	10.20e± 0.70
G2 C (+)	185.00a ±0.60	58.25a ±1.50	22.40a± 0.20
G3 (2.5% Popcorn)	124.40d±0.40	29.58d ±1.35	15.50c ± 0.40
G4 (5% Popcorn)	114.30e±0.30	19.64e ±0.20	12.65d±0.50
G5(2.5% Roasted corn)	137.00b ±1.20	41.83b ±2.35	16.90b±0.30
G6(5%Roasted corn)	127.50c ±1.10	33.43c ±0.40	15.63b± 0.20
G7 (2.5% mixture)	110.20f ±0.15	17.64e ±0.20	12.80d±0.30
G8 (5%mixture)	100.50g ±0.12	13.53f ± 0.22	11.50d ±0.20
LSD (P≤0.05)	2.450	1.520	1.170

Each value represents the mean ± SD of six replicates. Means in the same column with different letter are significantly different (P<0.05).

Data given in Table (3) showed the effect of different levels of popcorn, roasted corn, and their mixture as powder on serum lipid profile of diabetic rats. The obtained results indicated that positive control groups had higher values (P≤ 0.05) oftriglycerides (TG), total cholesterol (TC), low-density lipoprotein (LDL-c) and very low-density lipoprotein (VLDL-c) than negative control and treated groups. The vees versa recorded for high-density lipoprotein (HDL-c). These findings were in accordance previous findings of Hu *et al.*, [35] who showed a reduction in serum cholesterol levels when compared to those fed the control diet, when

corn or corn products were added to the atherogenic diet in Sprague-Dawley rats over a six-week period.

High-whole-grain diets are associated with reduced blood TAG, total and LDL-cholesterol, inflammatory markers, and increased plasma or serum enterolactone, as well as improved BMI and insulin sensitivity. The methods by which whole-grain cereals protect the gut and help prevent obesity, diabetes, cardiovascular disease, and cancer Newby *et al.*, [36].

These findings support those of Ludvik *et al*., [37], who suggest that HDL-c role in reverse cholesterol transport makes it a protective factor against atherosclerosis. HDL-c stimulates lipoprotein lipase, which is involved in the metabolism of triglyceride-rich lipoprotein.

Also, Jaleel *et al*., [38] discovered that higher lipid marker activity is linked to insulin resistance, metabolic disorder, and type 2 diabetes mellitus, as well as the therapeutic benefits of sweet potato methanol extract in diabetic rats.

Adamu *et al.,* [39] stated that after 45 days of feeding, the concentrations of VLDL and LDL for control groups were lower ($P \leq 0.05$) than that of corn grains group. Similarly, there were significant differences between all groups for values of VLDL and LDL after 91 days of study. Any significant alteration of lipids in their plasma levels could lead to a variety of clinical disorders in the affected animals.

Table (3): Effect of consumption different levels of popcorn, roasted corn, and their mixture on some lipid profile of diabetic rats

	Cholesterol (mg/dL)	Triglycerides (mg/dL)	HDL-c (mg/dL)	LDL-c (mg/dL)	VLDL-c (mg/dL)
G1 C (-)	88.0f ±0.20	72.0d ±0.20	46.5a ±1.20	27.1g±0.21	14.4d±0.21
G2 C (+)	135.0a±1.30	125.5a±1.50	30.5e±1.01	79.4a±1.20	25.1a±1.20
G3 (2.5% Popcorn)	110.0c± 0.50	84.0c ±1.20	38.2d ±1.43	55.0c ±1.72	16.8c ±1.72
G4 (5% Popcorn)	101.0d ±0.40	71.5d ±0.50	40.3c±0.30	46.3e±0.90	14.4d±0.90
G5(2.5% Roasted corn)	115.0b ±0.30	96.5b ±1.10	36.7d± 0.40	59.0b±1.60	19.3b±1.60
G6(5% Roasted corn)	103.0d ± 0.20	82.50c±1.40	36.53d±1.30	49.9d±2.20	16.5c±2.20
G7 (2.5% mixture)	93.0e ± 0.30	69.00e ±0.40	41.47c±0.20	51.5d±2.20	13.8d±2.20
G8 (5%mixture)	90.0e ± 0.20	66.00e ±0.30	43.41b±0.41	33.4f±2.20	13.2e±2.20
LSD ($P \leq 0.05$)	3.305	3.040	1.521	1.663	1.135

Each value represents the mean ± SD of six replicates. Means in the same column with different letter are significantly different ($P<0.05$).

Data tabulated in Table (4) shows the effects of consumption popcorn, roasted corn, and their combination powder on diabetic rats' kidney functions (serum uric acid, urea, and creatinine). The obtained results indicated that thepositive control groups had higher values ($P \leq 0.05$)

ofkidney functions (serum uric acid, urea, and creatinine] than negative control and treated groups. These findings support Sayed's [40], who found that diabetes induction disrupted an increase in serum urea, creatinine, uric acid, and urine albumin in the positive control group. This finding supports the theory that streptozotocin-induced diabetes results in diabetic nephropathy.

Our findings matched those of de-Vendômois *et al.,* [41], who found that the impairment in kidney function in male rats differed depending on whether they were given genetically modified corn. As previously admitted in the Monsanto corn recall, this is characterized by an increase in plasma creatinine levels and ion retention, both of which have been linked to chronic interstitial nephropathy [Hammond *et al.,* 42].

Conclusion

Consumption popcorn, roasted corn, or their mixture increased HDL-c significantly (P≤0.05) and improved serum glucose, kidney, and liver functions by lowering ALT, AST, ALP, creatinine, uric acid, and urea level.

Table (4): Effect consumption different levels of popcorn, roasted corn and their mixture powder on some kidney functions of diabetic rats

	Uric acid (mg/dL)	Urea (mg/dL)	Creatinine (mg/dL)
G1 C (-)	19.20h± 1.50	1.99b± 0.10	0.85c+ 0.20
G2 C (+)	50.00a ±2.60	3.89a ± 0.70	1.15a+ 0.15
G3 (2.5% Popcorn)	40.96d± 1.70	2.56b± 0.50	1.08a+ 0.03
G4 (5% Popcorn)	37.27e ± 1.10	2.19b± 0.40	1.00b+ 0.14
G5(2.5% Roasted corn)	47.13b± 1.50	3.20a ± 0.40	1.11a+ 0.03
G6(5% Roasted corn)	42.40c± 0.40	2.84a± 0.30	1.04a+ 0.05
G7 (2.5% mixture)	33.25f± 0.40	2.09b± 0.20	0.91b+ 0.02
G8 (5%mixture)	31.20g± 0.30	1.84b± 0.10	0.78c+ 0.04
LSD (P≤0.05)	2.064	1.160	0.125

Eachvalue represents themean ± SD of six replicates.Means in the same column with different letter are significantly different (P<0.05).

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التأثيرات المحتملة لتناول الفيشار والذرة المحمصة على الفئران المصابة بالسكر المستحث بالألوكسان

ألفت رشاد خاطر ، أمنية محمد عيد شعلان
قسم التغذية وعلوم الاطعمة، كلية الاقتصاد المنزلي، جامعة المنوفية، شبين الكوم، مصر

الملخص العربى:
الهدف من هذه الدراسة هو تقييم تأثير تناول الفشار والذرة المحمصة ومخلوطهما على الفئران المصابة بمرض السكر.تم تقسيم ٤٨ من ذكور الفئران البالغة وزنها (١٥٠±١٠ جم) إلى ثماني مجموعات ، كل منها ستة فئران. تمت إضافة الفشار والذرة المحمصة ومسحوقهما إلى الوجبة الرئيسية بمعدل ٢,٥٪ ، ٥٪ لمدة ٢٨ يومًا. تم حقن الألوكسان (١٥٠ مجم / كجم من وزن الجسم) تحت الجلد في الفئران لحدوث الأصابة بمرض السكر. تم قياسصورة دهون الدم (TG، TC، LDL-c، VLDL-c، HDL-c) ، ومستويات الجلوكوز ، ونشاط إنزيمات الكبد (ALT ، AST ، ALP) ، ووظائف الكلى (الكرياتينين ، وحمض البوليك ، ومستويات اليوريا). أشارت النتائج إلى أن تناول مسحوق الفشار أو الذرة المحمصة أو خليطهما أدى إلى زيادة HDL-cبشكل ملحوظ (P ≤0.05)وتحسين وظائف الكلى والكبد عن طريق خفض ALT, AST, ALP,الكرياتينين وحمض البوليك واليوريا والجلوكوز في دم الفئران. الخلاصة في الفئران ، أدى تناول الفشار المجفف والذرة المحمصة أو خليطهماإلى تقليل الآثار الغير مرغوبة لمرض السكر. كانت أفضل نتيجة هي تناولالمخلوط بنسبة ٥% من الفشار ومسحوق الذرة المحمص.

الكلمات المفتاحية: الحبوب ، مرض السكر, الفئران, التحاليل الكيميائية الحيوية.