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Effect of Fortified Diet with Avocado Fruits and Zinc Chloride of Rats Suffering from Diabetes and Osteoporosis

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Abstract

This study aimed to investigate the effect of fortified diet with avocado fruits and zinc chloride of rats suffering from diabetes and osteoporosis. Forty eight female Sprague-Dawley rats were divided into two main groups as follows: The first main group 6 rats fed on basal diet, as a control negative group. The second main group (42 rats) injected with alloxan monohydrate 90 mg/kg body weight to induced hyperglycemia. After 7 days serum glucose was determined in the first and second main groups to insure the induction. Rats in the second main group (diabetic rats) received oral prednisone acetate (4.5 ml/kg body weight/day twice a week) for two weeks to induce osteoporosis. After this period, the rats in the second main group were divided into seven subgroups (n= 6 rats) as follows: Subgroup (1): fed on basal diet (control positive group). Subgroup (2 and 3): were fed on basal diet containing 7.5% and 15% avocado fruits, respectively. Subgroup (4 and 5): were fed on basal diet containing 2g and 4g zinc chloride in the mineral mixture, respectively. Subgroup (6 and 7): were fed on basal diet containing (7.5% avocado fruits and 2g zinc chloride in the mineral mixture) and (15% avocado fruits and 4g zinc chloride in the mineral mixture),respectively. During the experimental period, the diets consumed and body weights were recorded twice weekly. The results showed that, the highest improvement in lipid profile recorded for the groups which were treated with diet containing (15% avocado and 4g zinc chloride in the mineral mixture), 7.5% avocado and 2g zinc chloride in the mineral mixture and 15% avocado, respectively. The highest levels of avocado fruits and zinc chloride together (15% avocado and 4g zinc chloride) recorded the best results in bone status. Serum glucose improved in groups which were treated with (15% avocado and 4g zinc chloride together), followed by the groups treated with (7.5% avocado and 2g zinc chloride together), and 4g zinc chloride, respectively. Serum and liver zinc increased gradually with increasing the levels of avocado and zinc chloride in the diets. From these results, it could be concluded that, the fortified diet with avocado fruits and zinc chloride improved the nutritional and biochemical parameters of diabetic rats suffering from osteoporosis.

Introduction

Diabetes has become a serious and increasing health problem in worldwide. About three hundred and eighty-two million people in the world suffering from diabetes in 2013, this number will arrive to five hundred and ninety-two in 2035 ***(Guariguata et al., 2014)***. Diabetic patients often suffer from osteoporosis ***(Schwartz, 2003)***.

Osteoarthritis is a disease that affects women in general after menopause; also, osteoporosis is a major problem in older men. Statistics show that 30 % of hip fractures occur for men. Statistics show also 1 in 8 men older than 50 years will have an osteoporotic fracture ***(Campion and Maricic, 2003)***.

Zinc is an essential mineral for human health. It is essential for the formation of collagen and deposition of minerals in the bones ***(Calhoun et al., 1974)***. On the other hand, zinc deficiency led to abnormalities in bone growth, bone formation, and mineralization in animals ***(Yamaguchi, 1998)***. In addition, deficiency of zinc associated with low bone mass in women ***(Angus et al., 1988)***. Urinary zinc excretion increased in women with osteoporosis, this phenomenon leads to decrease serum or plasma zinc concentration ***(Gur et al., 2002)***.

Rodríguez-Monforte et al., (2015) reported that, diet based on plant sources is associated with lower risk of cardiovascular disease CVDs. On the other hand, fruit play an important role in preventing CVDs. ***McCormack et al., (2010) and Fulgoni et al., (2013)*** reported that, avocado consumption is associated with reduced the risk of metabolic syndrome, because avocados contain a variety of vitamins, minerals and phytochemicals such as lutein, phenolic antioxidants, and phytosterols associated with numerous potential health benefits. The researchers reported that nutritionists should be aware of the beneficial associations between avocado intake, diet and health when making dietary recommendations.

Such minerals and vitamins play an important role in maintenance of healthy bone ***(Ilich and Kerstetter, 2000)***. Both zinc intake and blood zinc each have a positive association with bone mineral density BMD in men ***(Hyun et al., 2004)***. Zinc supplements in postmenopausal women may result a beneficial reduction in osteoporotic risk ***(Razmandeh et al., 2014)***.

The aim of the present study is to determine if supplemented diet with avocado fruits, zinc chloride and their combination alter the weight gain, lipid profile, bone status, glucose and zinc in serum and liver of rats suffering from osteoporosis.

Materials and Methods

Materials:

- Casein, vitamins, minerals, cellulose, choline chloride and alloxan obtained from El-Gomhoria Company, Cairo, Egypt.
- Fresh Avocado fruits *(Persea Americana)* was purchased from Field Crops Research Institute, Ministry of Agriculture Giza, Egypt.
- Glucocorticoid (prednisone acetate) will be obtained from the pharmacy , Cairo, Egypt.
- Starch and soy oil were obtained from local market.
- Normal 48 female albino rats Spraque - Dawely Strain (150 ± 5g) Purchased from Helwan Experimental Animals station.

Methods:

Preparation of avocado fruits.

Avocado fruits were washed by using tap water to remove dust, and then peeled off and the creamy pulps were homogenized using electric blender, according to the method described by ***(Alghamdi and Yousef, 2017)***.

Chemical analysis of Avocado.

Moisture, fiber, ash, protein and fat content were determined according to the method outlined in ***A.O.A.C. (2000)***. Total carbohydrates were determined by difference.

Biological Part:

Forty-eight Sprague – Dawley strain female albino rats, weighting (150 ± 5 g) used in this study. All rats fed on basal diet for 7 consecutive days to adaptation. Each rat was housed in an individual stainless steel cage under hygienic controlled condition. The basal diet consists of casein (14 %), corn oil (4%), choline chloride (0.25%), and vitamin mixture (1%), cellulose (5%) and the remainder is corn starch according to ***Reeves et al., (1993)***, salt mixture which used in these study prepared according to ***Hegsted et al., (1941)*** and vitamin mixture prepared according to ***A.O.A.C. (1975)***.

After adaptation period, the rats divided into two main groups as follows: The first main group (6 rats) fed on basal diet, as a control negative group. The second main group (42 rats) injected intraperitoneally (i.p.) with alloxan monohydrate 90 mg/kg body weight to induced hyperglycemia, according to ***(Ibegbulem and Chikezie, 2013)***. After 7 day serum glucose was determined in the first and second main groups to insure from the induction (65.786 ± 4.323 mg/dl) in the first main group vs. (121.321 ± 3.543 mg/dl) in the second main group. Rats in the second main group (diabetic rats) received oral prednisone acetate (4.5 ml/kg body weight/day twice a week) and fed on basal diet for two weeks to establish osteoporotic models according to ***Liao et al., (2003)***. After this period, the rats in the second main group were divided into seven subgroups (n= 6 rats) as follows: Subgroup 1: fed on basal diet (control positive group). Subgroup 2 and 3: were fed on basal diet containing 7.5% and 15% avocado fruits, respectively. Subgroup 4 and 5: were fed on basal diet containing 2g and 4g zinc chloride in the mineral mixture, respectively. Subgroup 6 and 7: were fed on basal diet containing (7.5% avocado fruits and 2g zinc chloride in the mineral mixture) and (15% avocado fruits and 4g zinc chloride in the mineral mixture), respectively.

During the experimental period (28 days), the diets consumed and body weights were recorded twice weekly according to ***Chapman et al., (1959)***. Blood samples were collected from the aorta at the end of the experiment period, after fasted overnight and anaesthetized. The blood samples were centrifuged and the serum was separated to estimate the following biochemical parameters, i.e. serum cholesterol according to ***(Allain et al., 1974)***, triglycerides ***(Foster and Dumns, 1973)***, high density lipoprotein (HDL-c) ***(Lopes-Virella et al., 1977)***, low density lipoprotein (LDL-c) and very low density lipoprotein (VLDL-C) ***(FriedWald et al., 1972)***, serum calcium ***(Baginski, 1973)***, serum phosphorus ***(Yee, 1968)***. Femur bones (Right and left) were removed from each rats, cleaned. Femur bones were put in a foil paper and kept in deep –freezer. Bone Mineral Density (BMD) and Bone Mineral Concentration (BMC) measured by Dual Energy X-ray Absorptiometry (DEXA) in National Research Center, Osteoporosis Unit. Calcium and phosphorus in femur bone of rats were determined according to the method described by ***Muynck and Vanhaecke, (2009)***. Serum glucose ***(Trinder, 1959)*** and zinc in serum and liver according to ***Jayalakshmi and Platel, (2016)***.

The obtained data was analyzed statistically for mean ± standard deviation and one-way ANOVA test ***(Sendecor and Cochran, 1979)***.

Results and Discussion

Chemical composition of avocado fruits.

The data in Table (1) revealed that, the amounts of moisture, protein, fat, ash, carbohydrates and fiber in avocado fruits were 65.18, 2.05, 15.51, 1.20, 9.00 and 7.06 g/100g, respectively. These results agree with ***(Alghamdi and Yousef, 2017)*** who reported that, the (moisture, protein, ash, carbohydrate, fiber and fat) contents in edible portion of avocado were 63 ; 2.12; 1.03; 9.87; 7.25 and 16.02 (g/100g edible portion), respectively.

Effect of fortified diet with avocado fruits and zinc chloride on feed intake and weight changes of rats suffering from diabetes and osteoporosis.

The effect fortified diets with two levels of avocado, zinc chloride and their combination on feed intake (g/day), weight (g) and body weight gain % of diabetic rats suffering from osteoporosis presented in Table (2). The mean value ± SD of feed intake (g/day/ each rat) of the control positive group fed on basal diet decreased significantly ($p \leq 0.05$), as compared to the negative control group (15.034 ± 0.212 vs. 16.910 ± 0.618 g), respectively. All treated groups showed significant increase ($p \leq 0.05$) in the mean value of feed intake, as compared to the positive control group, except the group, which was treated with 15% avocado fruits and the group treated with the combination of high levels from avocado and zinc chloride. In this respect, ***Wien et al., (2013)*** reported that, adding half avocado (70 g) in the lunch of overweight and moderately obese individuals increased the satiety from 3 to 5 subsequent hours, followed by a reduction of the insulin secretion.

Data presented in the same Table showed that, non-significant changes in the initial weight of healthy rats and other treated rats. On the other hand, final weight of the positive control group decreased significantly ($p \leq 0.05$), as compared to the negative control group. ***Zafar and Naqvithat, (2010)*** found that, the STZ-induced diabetes induced significant decrease in the body weight of diabetic animals. On the other hand, ***Jane et al., (2000)*** found that, administration of glucocorticoids at a dosage of 5 mg / kg/day for 5 days would result in a decrease in both body and diaphragm weights.

The mean value of final weight of the positive control group decreased by about 12.269%, than that of the negative control group. Final weights of all treated groups showed non-significant change, as compared to the positive control group.

The mean value of body weight gain % (BWG%) of the positive control group (diabetic rats which suffer from osteoporosis) decreased significantly ($p \leq 0.05$), as compared to the negative control group (healthy rats). All tested diet caused non-significant differences in BWG% ($p \leq 0.05$), except group of rats which treated with diet containing 7.5% avocado and 2g zinc chloride, as compared to the positive control group. In this respect, ***Chen et al., (2000)*** reported that zinc treatment did not affect body weight gain, body fat content or food intake in these diabetic mice. On the other hand, ***USDA, (2011) and Bes-Rastrollo et al., (2008)*** reported that, avocados are a medium energy dense fruit because avocado edible fruit consists of 72% water and 6.8% dietary fiber and has been shown to have similar effects on weight control as low-fat fruits and vegetables.

Effect of fortified diet with avocado fruits and zinc chloride on lipid profile of rats suffering from diabetes and osteoporosis.

Table (3) showed the effect of diets containing two levels of avocado, zinc chloride and their combinations on lipid profile including, serum cholesterol, triglyceride, high density lipoprotein-cholesterol (HDL-c), low density lipoprotein-cholesterol (LDL-c) and very low density lipoprotein-cholesterol (VLDL-c).

The mean values of serum cholesterol, triglyceride, LDL-c and VLDL-c in the positive control group increased significantly ($p \leq 0.05$), while HDL-c decreased, as compared to the negative control group. HDL-c lower in positive control group than that of the negative. ***Sultania et al., (2017)*** reported that, diabetes is a chronic disease, characterized by disorders of the metabolism of carbohydrates, fat and protein, resulting in a deficiency in the secretion of insulin, or the action of insulin or both. In addition, the dyslipidemia commonly occur in diabetes, included elevation of the levels of LDL-c and triglyceride, and lowering the levels of high-density lipoprotein cholesterol (HDL-C). On the other hand, prednisolone is a synthetic glucocorticoid that has been used over the last few decades' treatment of several diseases ***(Rhen and Cidlowski, 2005)***. The level of LDL-c increased significantly in patients receiving prednisolone as compared to the patients received hydrocortisone ***(Quinkler et al., 2017)***.

All tested groups improved the lipid profile, except triglyceride and VLDL-c in the group, which treated with diet containing 2g zinc chloride. Lipid profile improved gradually with increasing the levels of avocado, zinc chloride and (avocado and zinc chloride together). The highest improvement in lipid profile recorded for the groups which were treated with diet containing (15% avocado and 4g zinc chloride in the mineral mixture), (7.5% avocado and 2g zinc chloride in the mineral mixture) and 15% avocado, respectively.

In this respect, ***Riboli and Norat, (2003)*** reported that, fruits and vegetables decreased the risk of heart diseases. Avocado consumption improved the lipid profile including decreases serum total cholesterol, LDL-cholesterol and triglycerides and increases HDL-cholesterol levels, as compared to control diet subjects ***(LopezLedesma et al., 1996)***.

Healthy fats, such as mono and polyunsaturated fatty acids (MUFA) and (PUFA), has been associated with lower cardiovascular disease (CVD) risk in epidemiological studies ***(Schwingshack et al., 2011)***. On the other hand, ***Wang et al., (2010)*** *and* ***Dreher and Davenport, (2013)*** reported that avocado fruits are rich source in monounsaturated fatty acids (MUFAs), the average Hass avocado provides 136 g of edible fruit whose oil consists of 71% MUFAs, 13% PUFAs, and 16% SFAs. In addition to the fruit constituents of fiber, vitamins B, vitamins K1, vitamin E, magnesium and potassium, phytochemicals such as carotenoids, phenolics, and phytosterols, which play an important role in improving the lipid profile.

On the other side, ***Ranasinghe et al., (2015)*** reported that, supplementation of zinc reduced total cholesterol, low density lipoprotein- cholesterol and triglycerides significantly, and they reported also, zinc reduced the incidence of atherosclerosis related morbidity and mortality. In addition, different human studies have showed that zinc supplementation decreased the mean value of total cholesterol, low density lipoprotein-cholesterol and triglycerides, while increasing the mean value of high density lipoprotein-cholesterol ***(Hashemipour et al., 2009) and (Kadhim et al., 2006)***. Zinc-enriched diet has beneficial effects in cholesterol and triglycerides on basal and postprandial glycaemia ***(Ghayour-Mobarhan et al., 2005)***.

Effect of fortified diet with avocado and zinc chloride on bone status of rats suffering from diabetes and osteoporosis.

Diabetic rats which were suffering from osteoporosis (control positive group), showed significant decrease ($p \leq 0.05$) in femur bone (calcium "Ca" and phosphorus "P"), serum Ca and P, bone mineral density (BMD) and bone mineral concentration (BMC), as compared to healthy rats (control negative group). In this respect, ***(Leidig-***

Bruckner and Ziegler, 2001) reported that, osteoporosis is one of the most important diseases for people with diabetes.

On the other hand, ***Gudbjornsson et al.,(2002)*** reported that, glucocorticoid-induced osteoporosis (GIO) is one of the serious side effects, which have become the most common secondary osteoporosis in adults. ***Nishimoto et al (1985)*** reported that, imbalance between bone resorption and bone formation led to osteoporosis.

Treating diabetic rats, which were suffering from osteoporosis with diet containing (7.5% and 15% avocado fruits), 2g and 4g zinc chloride and their combinations, led to significant increase ($p \leq 0.05$) in all parameters calcium "Ca" and phosphorus "P" in the serum and bone, BMD and BMC, as compared to the positive control group (Table 4). The mean value of femur bone (Ca and P), serum (Ca and P), BMD and BMC increased gradually with increasing the levels of avocado fruits and zinc chloride. The highest concentration of these parameters recorded for the group which treated with diet containing (15% avocado and 4g zinc chloride together), followed by the group treated with diet containing (7.5% avocado and 2g zinc chloride) and 15% avocado, respectively.

The highest levels of avocado fruits and zinc chloride together (15% avocado and 4g zinc chloride) recorded the best results in bone status. This treatment increased the mean values of femur bone Ca, femur bone "P", serum Ca, serum "P", BMD and BMC by about 42.172%, 78.183%, 40.397%, 37.532%, 143.859% and 189.743% respectively, than that of the positive control group.

In this respect, ***Wang et al., (2010) and Dreher and Davenport ,(2013)*** reported that avocado fruits are rich source in monounsaturated fatty acids (MUFAs), the average Hass avocado provides 136 g of edible fruit whose oil consists of 71% MUFAs, 13% PUFAs, and 16% SFAs. ***Coetzee et al., (2007)*** reported that, omega-3 fatty acids (FAs) could prevent age-related bone loss by inhibiting osteoclastogenesis while improving osteoblast differentiation**.** Moreover, omega-3 FAs enhance calcium absorption by modifying the lipid composition of the intestinal cell membrane and decreasing intestinal calcium loss **(*Kruger and schollum, 2005)*.** On the other hand, the avocado fruits consists of fiber, vitamins B, vitamins K1, vitamin E, magnesium and potassium, phytochemicals such as carotenoids, phenolics, and phytosterols ***(Wang et al., 2012) and (Dreher and Davenport, 2013)***. Vitamin E supplements suppress serum gamma-tocopherol levels and may have negative effects on bone formation ***(Hamidi et al., 2012)***. Most of the experimental and clinical data available in the literature point to magnesium Mg as a contributor factor to bone health. Consequently, optimizing Mg intake might represent an effective and low-cost preventive measure against osteoporosis in individuals with documented Mg deficiency ***(Leidi et al., 2011)***. Dietary intake of β-carotene and β-cryptoxanthin may have a positive effect on bone health **(*Regu et al., 2017)***. Laboratory studies suggest that avocado and soy unsaponifiables (ASU) may facilitate repair of Osteoarthritis (OA) cartilage through its effect on osteoblasts ***(Dinubile,* 2010)**.

Hill et al., (2005) showed that a relationship between zinc nutritive status and bone turnover in elder adults. In addition to, ***Zhang et al., (2003) and Hambidge, (2003)*** reported that, rats need zinc to complete the physiological role of vitamin D in calcium metabolism, and they suggests that zinc may play an important role in bone health. ***Relea et al., (1995) and Herzberg et al., (1990)*** reported that, zinc secretion is increased in the urine in osteoporotic women. On the other side, ***Spencer et al., (2013)*** shown that high zinc consumption decreased the absorption of calcium in the intestine during a low calcium intake, while did not occur during a normal calcium intake.

Effect of fortified diet with avocado and zinc chloride on serum glucose, zinc in serum and liver of rats suffering from diabetes and osteoporosis.

Injected rats with alloxan and treated with prednisone acetate (positive control group) increased the mean value of serum glucose and decreased the mean values of zinc in serum and liver significantly ($p \leq 0.05$), as compared to healthy rats (control negative group), (146.800 ± 2.387 mg/dl, 136.720 ± 2.942 µg/dl and 21.890 ± 0.880 µg/g) vs. (81.400 ± 3.361 mg/dl, 179.280 ± 4.432 µg/dl and 33.196 ± 1.511 µg/g), respectively. In this respect, ***Stanely et al., (2004)*** reported that, alloxan induces diabetes by damaging the insulin secreting cells of the pancreas leading to hyperglycemia. In addition to, ***Kahn et al., (1978)*** reported that, administration of glucocorticoids in vivo may also impair insulin binding to target cells, and this could provide another cause for glucocorticoid-induced insulin resistance.

On the other side, ***Daradkeh et al., (2014)*** reported that, zinc deficiency is common among type 2 diabetic patients due to hyperglycemia and polyuria. In addition, the low zinc status in conjunction with abnormal BMD may be strongly associated with osteoporosis in the studied patients ***(Al-Timimi et al., 2017)***.

The mean value of serum glucose increased in the positive control group by about 80.343%, than that of the negative control group. All treated diabetic groups that suffer from osteoporosis with two levels from avocado, zinc chloride and their combinations showed significant decrease ($p \leq 0.05$) in serum glucose, as compared to the positive control group. On the other hand, serum glucose decreased gradually with increasing the levels of avocado and zinc chloride.

The highest decrease in the mean value of serum glucose recorded for the group treated with diet containing (15% avocado and 4g zinc chloride together), followed by the groups treated with (7.5% avocado and 2g zinc chloride together), and 4g zinc chloride, respectively.

In this respect, ***Oboh et al., (2014)*** reported that, extracts of phenolic compounds from avocado leaves or fruits led to inhibit the activity of enzymes related to the development of Type 2 Diabetes (α-amilase and α-glucosidase), as well as the malondialdehyde production (MDA), a marker of oxidative stress and responsible for increasing the lipid peroxidation. Also, ***Rao and Adinew, (2011)*** reported that, the hypoglycemic effect of the avocado fruits nay be due to its ability to stimulate the remaining pancreatic β-cells in animal models, making them able to secrete more insulin. Mono unsaturated fatty acids are considered alternatives for the dietary treatment of Type 2 Diabetes ***(Ros, 2003)***, avocado have a substantial amount of Mono unsaturated fatty acids it could be used as an option for glycemic control in diabetic patients. While ***Wien et al., (2013)*** reported that, adding half avocado (70 g) in the lunch of overweight and moderately obese individuals increased the satiety from 3 to 5 subsequent hours, followed by a reduction of the insulin secretion.

Khan and Safdar, (2003) reported that, zinc is an important mineral. Zinc has an active role in the metabolism of glucose and fat, and has a vital role in hormone function and also wound healing. Zinc is necessary for health and growth, and it is necessary for the function and activities of enzymes. On the other hand, ***Toma et al., (2014)*** decided that that, zinc plays an important role in the synthesis, storage and secretion of insulin. It also has an effective role in managing blood glucose and reducing its complications. Supplementation of zinc in rats before treatment with alloxan or dithiozone prevented hyperglycemia and destruction of islets ***(Jansen et al, 2009)***.

Zhang et al.,(2012) reported that reduced hepatic zinc concentration were found in diabetics mice Zinc deficiency has contributed to increase serum concentrations of ALT and deposit of lipids in the liver of the mice.

The mean value of zinc in (serum and liver) decreased in the positive group by about 23.739% and 34.058% respectively, than that of the negative group. Treating groups, which suffer from diabetes and osteoporosis with diets containing two levels from avocado, zinc chloride and their combination, led to significant increase ($p \le 0.05$) in the mean value of serum and liver zinc, as compared to the positive control group. Serum and liver zinc increased gradually with increasing the levels of avocado and zinc chloride in the diets.

Treated diabetic rats, which suffer from osteoporosis with the two levels from zinc chloride, increased the mean values of serum and liver zinc significantly ($p \leq 0.05$) , as compared to the rats treated with the two levels from avocado.

Feeding diabetic rats, which suffer from osteoporosis on diet containing 15% avocado and 4g zinc chloride, recorded the best results in serum and liver zinc, followed by the group, which fed, on diet containing 7.5% avocado and 2g zinc chloride and also the group fed on diet containing 4g zinc chloride, respectively.

Low serum zinc concentrations can be the result of low zinc dietary intake; urinary zinc excretion is higher in osteoporotic women than women with no osteoporosis ***(Relea et al., 1995) and (Herzberg et al., 1990)***. On the other side, ***Sadighi et al., (2008)*** reported that, one study in Iran showed that, serum zinc decreased significantly in patients with bone fractures, as compared to the normal range; on the other hand, supplementation diet with zinc led to significant increase of this parameter and had positive effect on callus formation.

Conclusion

Fortified diet with avocado fruits and zinc chloride improved the nutritional and biochemical parameters of diabetic rats which suffering from osteoporosis.

Table (1): Chemical composition of avocado fruits (g/100g).

Nutrients	Amounts (g)
Moisture	65.18
Protein	2.05
Fat	15.51
Ash	1.20
Carbohydrate	9.00
Fiber	7.06

Table (2): Effect of fortified diet with avocado fruits and zinc chloride on feed intake and weight changes of rats suffering from diabetes and osteoporosis.

Parameters / Groups	Feed intake (g/day/rat)	Initial weight (g)	Final weight (g)	BWG%
Control (-ve)	16.910 [a] ± 0.618	149.400 [a] ± 4.827	195.600 [a] ± 7.700	30.902 [a] ± 1.722
Control (+ve)	15.034 [e] ± 0.212	150.000 [a] ± 2.738	171.600 [b] ± 2.073	14.408 [b] ± 1.098
7.5% avocado	15.840 [d] ± 0.260	150.600 [a] ± 1.949	170.00 [b] ± 0.707	12.893 [b c] ± 1.161
15% avocado	15.404 [e] ± 0.289	151.400 [a] ± 2.073	170.800 [b] ± 3.271	12.810 [b c] ± 1.230
2g zinc chloride	15.900 [c d] ± 0.353	150.800 [a] ± 2.774	171.400 [b] ±3.361	13.659 [b] ± 0.707
4g zinc chloride	15.992 [c d] ± 0.195	150.000 [a] ± 2.915	168.800 [b] ± 2.774	12.541 [b c] ± 0.986
7.5% avocado and 2g zinc chloride	16.534 [b] ± 0.201	150.000 [a] ± 3.535	168.600 [b] ± 3.714	9.737 [c] ± 5.456
15% avocado and 4g zinc chloride	15.530 [e] ± 0.270	149.600 [a] ± 3.209	168.600 [b] ± 4.098	12.699 [b c] ± 1.202

BWG%: Body weight gain%. All results are expressed as mean ± SD. Values in each row which have different litters are significant different ($p \leq 0.05$).

Table (3): Effect of fortified diet with avocado fruits and zinc chloride on lipid profile of rats suffering from diabetes and osteoporosis.

Parameters / Groups	Lipid Profile (mg/dl)				
	Cholesterol	Triglyceride	HDL-c	LDL-c	VLDL-c
Control (-ve)	78.400 [f] ± 2.701	37.800 [e] ± 2.280	42.600 [a] ± 0.894	28.240 [f] ± 2.535	7.560 [e] ± 0.456
Control (+ve)	190.400 [a] ± 3.646	93.200 [a] ± 3.962	17.400 [f] ± 2.073	154.360 [a] ± 4.257	18.640 [a] ± 0.792
7.5% avocado	178.200 [c] ± 1.788	84.000 [b] ± 3.674	23.400 [d] ± 2.180	138.000 [c] ± 2.989	16.800 [b] ± 0.734
15% avocado	163.200 [d] ± 3.114	72.400 [c] ± 2.509	30.000 [c] ± 1.581	118.720 [d] ± 2.625	14.480 [c] ± 0.502
2g zinc chloride	184.800 [b] ± 1.483	89.600 [a] ± 4.037	20.400 [e] ± 1.516	146.480 [b] ± 1.404	17.920 [a] ± 0.807
4g zinc chloride	174.400 [c] ± 1.516	83.400 [b] ± 4.393	24.800 [d] ± 1.788	133.466 [c] ± 3.328	16.134 [b] ± 1.626
7.5% avocado and 2g zinc chloride	163.600 [d] ± 4.159	72.600 [c] ± 3.646	30.600 [c] ± 2.408	118.480 [d] ± 4.016	14.520 [c] ± 0.729
15% avocado and 4g zinc chloride	146.800 [e] ± 5.069	60.800 [d] ± 3.033	37.600 [b] ± 1.816	97.040 [e] ± 5.563	12.160 [d] ± 0.606

All results are expressed as mean ± SD. Values in each row which have different litters are significant different ($p \leq 0.05$).

Table (4): Effect of fortified diet with avocado and zinc chloride on bone status of rats suffering from diabetes and osteoporosis.

Parameters / Groups	Bone status					
	FB (Ca) (mg)	FB (P) (mg)	S (Ca) mmol/l	S (P) mmol/l	BMD g/cm^2	BMC g/cm^2
Control (-ve)	96.839 ^{a} ± 3.048	59.354 ^{a} ± 2.342	3.356 ^{a} ±0.065	2.460 ^{a} ± 0.080	0.178 ^{a} ± 0.009	0.126 ^{a} ± 0.008
Control (+ve)	57.784 ^{f} ± 3.381	31.691 ^{f} ± 1.421	2.213 ^{f} ±0.119	1.540 ^{f} ± 0.069	0.057 ^{g} ± 0.006	0.039 ^{f} ± 0.004
7.5% avocado	65.324 ^{de} ± 3.164	39.674 ^{e} ± 1.554	2.519 ^{d} ±0.069	1.789 ^{d} ± 0.081	0.080 ^{e} ± 0.009	0.064 ^{e} ± 0.006
15% avocado	73.748 ^{c} ± 2.138	46.489 ^{c} ± 1.926	2.801 ^{c} ±0.076	1.942 ^{c} ± 0.032	0.111 ^{c} ± 0.011	0.090 ^{c} ± 0.007
2g zinc chloride	62.128 ^{e} ± 2.796	37.676 ^{e} ± 1.875	2.384 ^{e} ±0.084	1.652 ^{e} ± 0.075	0.070 ^{f} ±0.003	0.059 ^{e} ± 0.003
4g zinc chloride	66.738 ^{d} ± 2.864	42.288 ^{d} ± 0.824	2.591 ^{d} ±0.077	1.774 ^{d} ± 0.049	0.095 ^{d} ±0.001	0.080 ^{d} ± 0.004
7.5% avocado and 2g zinc chloride	70.736 ^{c} ± 2.745	44.109 ^{d} ± 1.402	2.756 ^{c} ±0.041	2.035 ^{b} ± 0.040	0.108 ^{c} ±0.007	0.086 $^{c\,d}$ ± 0.007
15% avocado and 4g zinc chloride	82.153 ^{b} ± 2.122	56.468 ^{b} ± 2.306	3.107 ^{b} ±0.071	2.118 ^{b} ± 0.100	0.139 ^{b} ±0.003	0.113 ^{b} ± 0.005

All results are expressed as mean ± SD. Values in each row which have different litters are significant different ($p \leq 0.05$).

Table (5): Effect of fortified diet with avocado fruits and zinc chloride on serum glucose, zinc in serum and liver of rats suffering from diabetes and osteoporosis.

Parameters / Groups	Serum glucose (mg/dl)	Serum zinc µg/dl	Liver zinc µg/g
Control (-ve)	81.400 [g] ± 3.361	179.280 [a] ± 4.432	33.196 [a] ± 1.511
Control (+ve)	146.800 [a] ± 2.387	136.720 [f] ± 2.942	21.890 [f] ± 0.880
7.5% avocado	132.800 [b] ± 2.774	145.060 [e] ± 2.768	24.494 [e] ± 0.777
15% avocado	119.000 [c] ± 2.345	153.500 [d] ± 3.376	26.812 [d] ± 0.725
2g zinc chloride	129.400 [b] ± 2.880	151.360 [d] ± 2.740	26.822 [d] ± 0.898
4g zinc chloride	114.200 [d] ± 3.563	159.640 [c] ± 2.865	28.306 [c] ± 0.517
7.5% avocado and 2g zinc chloride	102.600 [e] ± 2.073	160.880 [c] ± 3.433	28.550 [c] ± 0.916
15% avocado and 4g zinc chloride	90.200 [f] ± 3.962	170.240 [b] ± 3.667	30.582 [b] ± 0.729

All results are expressed as mean ± SD. Values in each row which have different litters are significant different (p≤0.05).

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تأثير النظام الغذائي المدعم بالأفوكادو و كلوريد الزنك على الفئران المصابة بالسكر وتعاني من هشاشة العظام

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الملخص العربي

تهدف هذه الدراسة لبحث تأثير النظام الغذائي المدعم بالأفوكادو و كلوريد الزنك على الفئران المصابة بالسكر وتعاني من هشاشة العظام. تم أُستخدم ٤٨ من إناث الفئران من فصيلة سبارج داولي في هذه الدراسة , تم تقسيمهم إلى مجموعتين رئيستين المجموعة الأولى الرئيسية (٦ فئران) تم تغذيتها على الغذاء الأساسي وهي المجموعة الضابطة السالبة والمجموعة الثانية الرئيسية (٤٢ فأر) , تم حقن الفئران بمادة الألوكسان مونوهيدريت (٩٠ملجم ألوكسان / كجم من وزن الجسم) لإحداث الإصابة بمرض السكر وبعد مرور ٧ أيام تم تقدير مستوى الجلوكوز بالمجموعة الأولى و الثانية للتأكد من إحداث الإصابة بمرض السكر. وبعد هذه المدة تم اعطاء فئران المجموعة الرئيسية الثانية مادة بريدنيزون اسيتيت بالفم (٥و٤ مل/ كجم من وزن الجسم / يومياً / مرتين بالأسبوع) لمدة اسبوعين لإحداث هشاشة العظام. تم تقسيم المجموعة الرئيسية الثانية لسبع مجموعات فرعية (٦ فئران لكل مجموعة) كالآتي: المجموعة الفرعية الاولي تم تغذيتها على الغذاء الأساسي (المجموعة الضابطة الموجبة) والمجموعتين الفرعيتين (٢ و ٣) تم تغذيتهم على الغذاء الأساسي المحتوي على ٥و٧% و ١٥% من الأفوكادو على التوالي. المجموعتين الفرعيتين (٤ و ٥) تم تغذيتهم على الغذاء الأساسي المحتوي على ٢ و ٤ جرام من كلوريد الزنك على التوالي. المجموعتين الفرعيتين (٦ و٧) تم تغذيتهم على الغذاء الأساسي المحتوي على (٧,٥% من الأفوكادو و ٢ جرام من كلوريد الزنك) و (١٥% من الأفوكادو و ٤ جرام من كلوريد الزنك) على التوالي . و خلال مدة التجربة (٢٨ يوم) تم تقدير الغذاء المتناول و وزن الجسم مرتين أسبوعين. وقد أظهرت النتائج أن أفضل تحسن في صورة دهون الدم سُجل بالمجموعات التي تغذت على الغذاء الأساسي المحتوي على ٥و٧%من الأفوكادو و ٢ جرام من كلوريد الزنك تلتها المجموعة التي تم تغذيتها على الغذاء الأساسي المحتوي على ١٥% من الأفوكادو و ٤ جرام من كلوريد الزنك على التوالي. المستويات المرتفعة من الأفوكادو و كلوريد الزنك معاً (١٥% من الأفوكادو و ٤ جرام من كلوريد الزنك) قد سجلت أفضل تحسن في حالة العظام .المجموعات المعالجة التي تعاني من الإصابة بالسكر و هشاشة العظام التي تم تغذيتها على

الغذاء الأساسي المحتوي على ٧,٥%من الأفوكادو و ٢ جرام من كلوريد الزنك تلتها المجموعة التي تغذت على الغذاء الأساسي المحتوي على ١٥% من الأفوكادو و ٤ جرام من كلوريد الزنك على التوالي قد أدى لتحسن مستوى جلوكوز الدم. نسبة الزنك بالدم و بالكبد قد ارتفع تدريجياً بزيادة نسبة الأفوكادو و كلوريد الزنك بالنظام الغذائي . نستخلص من هذه النتائج أن النظام الغذائي المدعم بالأفوكادو و كلوريد الزنك أحدث تحسن في القياسات الغذائية والحيوية على الفئران المصابة بالسكر وتعاني من هشاشة العظام.