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المجلة العلمية المحكمة لدراسات وبحوث التربية النوعية

المجلد العاشر – العدد الرابع – الجزء الثاني – مسلسل العدد (٢٧) – أكتوبر ٢٠٢٤م

رقم الإيداع بدار الكتب ٢٤٢٧٤ لسنة ٢٠١٦

ISSN-Print: 2356-8690 ISSN-Online: 2974-4423

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

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Abstract

Obesity is abnormal or excessive fat accumulation that may impair health and osteoporosis is a characterized by the loss of bone mass, osteoporosis affects many of females. Chia seeds are a nutrient good source of mineral and vitamin that can be used in a diet to avoid bone diseases such as obesity, rickets and osteoporosis. This research examined the value of chia seeds in diets and how they protected rats from the effects of obesity and osteoporosis. chemical composition of chia seeds moisture, protein, fat, ash, fiber and minerals contents were determined in dry weight (D.w). It contains a high percentage of calcium, potassium, magnesium and phosphorus. The present study carried out on twenty-five female rats (Sprague Dowely) weighing (170 ±5 g). The first group kept as negative control group which fed on basal diet only while groups from (2-5) were induction with high fat diet and injections of dexamethasone once a week at dose (7mg/kg b. wt / rats) for up to four weeks. Group (2) positive group (+ve). Group (3-5) were fed on basal diet that was supplemented with 3%, 6% and 9% chia seeds for 60 days. The results revealed that all of the treated groups showed significant increases in HDL, superoxide dismutase (SOD) and catalase, in addition to the emergence of a significant improvement in urea, uric acid, creatinine, liver function, CH, TG, LDL, VLDL, malondialdehyde (MDA), glucose and insulin, comparing to positive control group. Our results demonstrate that chia seeds powder have beneficial effects on obesity and osteoporosis risk factors.

KEY WORDS: Chia Seeds, Obesity, Osteoporosis, Dexamethasone, and Bone Mineral Density.

التأثير الكيميائي والبيولوجي لبذور الشيا على تحسين الحالة الصحية للفئران البدينة

الملخص العربى

السمنة هي تراكم غير طبيعي أو مفرط للدهون التى قد تؤثر بالصحة.كما أن هشاشة العظام هي حالة تتميز بفقدان الكتلة العظمية، مما يؤثر على العديد من الإناث. بذور الشيا هي مصدر جيد للمغذيات والمعادن والفيتامينات التي يمكن استخدامها في النظام الغذائي لتجنب

أمراض العظام مثل السمنة والكساح وهشاشة العظام. يدرس هذا البحث قيمة بذور الشيا في الأنظمة الغذائية و هل لها تأثير وقائى على الفئران من التأثيرات الضارة للسمنة وهشاشة العظام. تم تقييم التركيب الكيميائي لبذور الشيا مثل الرطوبة، البروتين، الدهون، الرماد، الألياف ومحتويات المعادن بالوزن الجاف (D.w). تحتوي بذور الشيا على نسبة عالية من الكالسيوم والبوتاسيوم والمغنيسيوم والفوسفور. أجريت الدراسة الحالية على خمسة وعشرين فأرة أنثى (Sprague Dowely) وزنها (١٧٠ ± ٥ جم). المجموعة الأولى أبقت كمجموعة تحكم سلبية والتي تغذت على الغذاء الأساسي فقط في حين تم تحريض المجموعات من (٢-٥) بنظام غذائي عالي الدهون وحقن ديكساميثازون مرة واحدة في الأسبوع بجرعة (٧ ملغ / كجم وزن الجسم / الفئران) لمدة تصل إلى أربعة أسابيع. المجموعة (٢) مجموعة إيجابية (+ve). تم تغذية المجموعة (٣-٥) على نظام غذائي أساسي مكمل ببذور الشيا ٣٪ و ٦٪ و ٩٪ لمدة ٦٠ يومًا. أظهرت النتائج أن جميع المجموعات المعالجة أظهرت زيادات كبيرة في HDL و superoxide dismutase (SOD) و catalase ، بالإضافة إلى ظهور تحسن كبير في اليوريا وحمض البوليك والكرياتينين ووظائف الكبد و CH و TG و LDL و VLDL و malondialdehyde (MDA) والجلوكوز والأنسولين ، مقارنة بمجموعة التحكم الإيجابية. توضح نتائجنا أن مسحوق بذور الشيا له تأثيرات مفيدة على عوامل خطر السمنة وهشاشة العظام.

الكلمات المفتاحية: بذور الشيا، والسمنة، وهشاشة العظام، والديكساميثازون، وكثافة المعادن في العظام.

INTRODUCTION

The World Health Organization (WHO) defines obesity as "abnormal or excessive fat accumulation that may impair health," adding that "the fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended". **Ibrahim *et al.*, (2021).**

The prevalence of obesity appears to be influenced by important social variables as well. Obesity and comorbidities connected to obesity are far more common in impoverished communities. According to an analysis of the National Health Interview Survey, higher rates of obesity were linked to higher burdens of unfavorable social determinants of health, such as food security, educational attainment, community cohesion, and healthcare access. The most burdened quartile had relative rates of BMI of 30 to 40 kg/m2 and above 40 kg/m2, respectively, that were 50% and 75% higher **Javed *et al.*, (2022).**

Osteoporosis is a progressive bone disease that is characterized by a decrease in bone mass and density that can lead to an increased risk of fracture. Osteoporosis is characterized by decreased bone mineral density (BMD), deteriorating bone microarchitecture, and changes in the quantity and diversity of proteins in bone. According to dual-energy X-ray absorptiometry measurements, osteoporosis is defined by the World Health Organization (WHO) as a bone mineral density that is 2.5 standard deviations or greater below the mean peak bone mass**. Mohamad *et al.*, (2018)**

Osteoporosis is a gradual skeletal condition that reduces bone strength, density, and quality, increasing the risk of fracture. It is associated with low bone mineral density and loss of structural and biomechanical properties that are vital for the maintenance of bone homeostasis **Hsu *et al.*, (2020).**

Dexamethasone (DEX) is a type of glucocorticoid (GCs) extensively used as a treatment of allergic disorders, ulcerative colitis, arthritis, pulmonary disorders, and organ transplantation, owing to its potent anti-inflammatory and immunomodulatory effects **Vandewalle *et al.*, (2018).** The therapeutic value of compounds found in plants and their extracts has been known for centuries, resulting in their utilization for the treatment of many ailments. Although the improvement observed in the world, plant-based drugs are still being used to treat many pathological or as alternatives to modern medicines **Dzobo, (2022).**

Chia seeds is grown in Egypt and throughout the world **Motyka *et al.*, (2022).** this plant grows in a region spanning western Mexico to northern Guatemala. Its leaves are 4–8 cm long and 3–6 cm broad, and it is 1 meter tall. A warm environment with lots of rainfall and a temperature range of 15 to 30 °C is ideal for its cultivation. Chia seeds are utilized extensively for their health advantages and are native to the Lake Patzcuaro, Michoacan, and Mexico areas. Their hue ranges from red and white to black **Abdel Ghani *et al.*, (2023).**

Chia seeds have therapeutic importance. It contains more than one functional component. The importance of these components can suppress the risk of chronic diseases including GI-tract-related diseases, CVD, osteoporosis, and various types of cancer. Fiber, omega-3 fatty acids, protein, polyphenols, phytosterols, vitamins, and minerals reduce heart diseases by controlling bad cholesterol, hypertension, and platelet aggregation. In the GI tract, chia seed components reduce type 2 diabetes by improving the beta-cell performance and reducing the blood glucose level. Moreover, chia seeds have rich fiber that provides bulk to stool, so these seeds can prevent constipation. However, antioxidants and phenolic parts of these seeds improve oxidation and aid in reducing the risk of

different types of cancer. In the future, Chia seed components may be used as an additive ingredient in different food products such as meat products and baking products to improve the nutrition value and shelf stability **Khalid *et al.*, (2023).**

Chia has gained recognition as a "seed for the first 21st century" due to its priceless nutraceutical advantages. Chia can be recognized as the new golden and super seed, with several health advantages **Orona and Paredes (2024).**

This study aimed to investigate the potential beneficial effects of chia seed powder on obesity and osteoporosis induced by high-fat diet and dexamethasone in female rats.

MATERIALS and METHODS

MATERIALS

1. **Chia Seeds:** (*Salvia Hispanic L.*) was obtained from the Agriculture Research Center, Giza, Egypt.
2. **Dexamethasone (DEX):** sodium phosphate was purchased as ampules (8mg/2ml) from Amriya Pharmaceutical Industries Alexandria, Egypt.

Animals

Twenty-five female of albino rats (Sprague Dawley) weighting (170 ±5 g), obtained from experimental animal house in Agricultural Research Center, Giza, Egypt. The animals were kept under normal laboratory conditions for seven days before experiment and fed one week on standard diet (14% casein (protein >80%), corn oil 4%, choline chloride 0.25%, vitamin mixture 1%, salt mixture 3.5%, fiber 5% and the remainder corn starch) for adaptation according to (NRC 1995) and water ad libitum.

METHODS

Preparation of chia seeds powder:

Seeds of chia were thoroughly checked to remove any impurities, then they were ground into a powder. Whole seed powder was saved in well-closed, opaque glass jars in the refrigerator to prevent lipid oxidation until used in diet preparation **Barakat *et al.*, (2022).**

Chemical composition of chia seeds:

According to **A.O.A.C (2019)** Moisture, protein, fat, ash and fiber contents in dry weight (D.w) were determined according to the methods. Total carbohydrates were calculated as following: Total carbohydrates% = 100 - (moisture % + protein % + fat % + ash %).

Minerals of chia seeds:

According to **Bettinelli *et al.*, (2000)** the minerals concentration was determined using Inductivity Coupled Plasma (iCAP™ 7000 Plus Series ICP-OES, Thermo Scientific™) after acid digestion using HNO3 (69%) and H2O2 (30%) in a microwave digestion apparatus (model Milestone MLS 1200 Mega).

Induction of obesity

Obesity was induced in rats by fed on a high-fat diet [casein 14% (protein >80%), Choline chloride 0.25%, vitamin mixture 1.0%, salt weed 3.5%, fibers 5%, L-Cystine 0.18%, sucrose 10%, 20% fat for 4 weeks according **to Liu *et al.*, (2004).**

Induction of osteoporosis by dexamethasone

Osteoporosis was induced in rats by intramuscular injection of DEX at a dose (7mg/kg b. wt) once a week for up to four weeks according to **Thakur *et al.*, (2013).**

Experimental design

Twenty-five female of albino rats were randomly divided into five groups (n=5/group) as follow:

Group 1: Negative control group (-ve) doesn't receive any treatment.

Group 2: Positive control group (+ve) obesity and osteoporosis rats without treatment.

Group 3: Treated group with 3% chia seeds powder of basal diet.

Group 4: Treated group with 6% chia seeds powder of basal diet

Group 5: Treated group with 9% chia seeds powder of basal diet.

After the end of the 60 days (experiment duration), rats were subjected daily to a physical examination for observation of their general body condition such as external appearance, the color of hair, fatigue and lethargy, abnormal movements, and discomfort walking weekly change in body weight gain (BWG) and feed efficiency ratio (FER) were monitored. Feed intake (gm.) was determined weekly according to **Chapman *et al.*, (1959).** All rats were killed by overdose chloroform, and then blood samples were collected from the eye of the venous plexus using a capillary tube in clean, dry centrifuge tubes. Then separate the serum using a centrifuge at 4000 rpm for 10 min and kept at 18 °C until analysis according to **El-Refai *et al.*, (2015).**

Institutional review board statement: All experimental animals in this study were managed according to the guidelines for the Care and Use of Laboratory Animals in Neuroscience and Behavioral Research and were approved by the Research Ethics Committee, Home Economics Department, nutrition and food science, Mansoura University, Egypt, under animal protocol code No (R/14).

Biological estimations

Determination of (BWG), (BWG%), Feed intake, and (FER)

Body weight gain (BWG) and Feed intake (gm.) were monitored weekly. feed efficiency ratio (FER) was determined according to **Chapman *et al.*, (1959).**

Body weight gain (BWG) and feed efficiency ratio (FER) were calculated:

*Body weight gain = Final weight (g) – Initial weight (g)

* Body weight gain $BWG(\%) = \frac{\text{final weight(g)} - \text{intial weight(g)}}{\text{intial weight(g)}} x100$

*Feed efficiency ratio (FER) = Body weight gain (g) / Food intake (g) / Number of days of experiment

Determination of kidney function

Serum urea was determined according to **Malhotra, (2003),** Uric acid and creatinine were determined according to the methods described by **Tietz, (1995), and Barthes, *et al.*, (1972).**

Determination of liver function

Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) activities were analyzed according to the method of **Reitman and Frankel (1957)** using kits bought from Randox Company (UK). Alkaline phosphatase (ALP) activity was determined according to the method described by **Belfield and Goldberg (1971),** using kits purchased from Reactivos Spinreact Company (Spain).

Determination of Lipid profile

Serum Triglycerides was determined according to **Tietz, (1995),** Serum Total cholesterol was determined according to **Jain *et al.*, (2017),** Serum high-density lipoprotein cholesterol (HDLc) was determined according to **Lopes *et al.*, (1977),** Low-density lipoprotein cholesterol (LDLc) and very low-density lipoprotein cholesterol (VLDLc) were calculated by using the method of **Friedewald *et al.*, (1972).**

Determination of on anti-oxidant catalase (CAT), superoxide dismutase (SOD) and free radical malondialdehyde (MDA)

The activity of antioxidant enzyme superoxide dismutase (SOD) was estimated according to the method described by **Burda, (2001),** The activity of the antioxidant enzyme catalase (CAT) was determined according to the method of **Beutler, (1963).** And Lipid peroxide was estimated by spectrophotometry of lipid peroxide, malondialdehyde (MDA) by **Ohkawa *et al.*, (1979).**

Determination of serum glucose and insulin levels

serum insulin was estimated according to **Sapin *et al.*, (2001)** and Glucose was measured according to **Srikanth *et al.*, (2004).**

Statistical analysis:

The collected data were presented as means with standard deviations (means±S.D.), statistical analysis was performed using one-way analysis of variance (ANOVA), and the means between groups were compared using the least significant difference (LSD) statistic test. All tests were

completed using the computer program of the statistical analysis program (SPSS, version 24, 2016), according to **Armitage and Berry (1987)**

RESULT AND DISCUSSION

Chemical composition of chia seeds powder

The data in Table (1) showed chemical composition of the content in percent of ash, moisture, fat, protein, fiber, and carbohydrate. It noticed that the highest percentages chemical composition of chia seeds are as the following: carbohydrate content is (53.37±0.33 %), fiber content is (52.96±0.13%), fat content is (31.87±0.08%), moisture content is (7.73±0.12%), ash content is (3.98±0.07%), and protein content is (3.05±0.06%).

The chemical composition results were almost identical to those of **Segura-Campos *et al.*, (2014), Coelho *et al.*, (2019), Cotabarren *et al.*, (2019), and Lara *et al.* (2021).** Prior research has shown that chia seeds are a rich source of dietary fiber, dietary lipids, carbs, and ash, with amounts of 41, 30, 4, and 30%, respectively.

These results are almost in line with those published by **Mohammed *et al.*, (2019),** who reported that percentages of lipids (33.9%), moisture (7.3%), and ash (4.77%) were found in the proximate analysis of chia seeds (Cs) on a dry weight basis.

The chemical compositions of some seeds are an excellent source of vital nutritional substances related with health promotion and illness prevention **(Senila *et al.*, 2021).**

TABLE 1 Chemical composition (%) of raw Chia seeds

Variables	%
Ash	**3.98±0.07**
Moisture	**7.73±0.12**
Fat	**31.87±0.08**
Protein	**3.05±0.06**
Fiber	**52.96±0.13**
Carbohydrates	**53.37±0.33**

Each value is average repetition three times, whereas illustrating mean ± SD.

Minerals of chia seeds

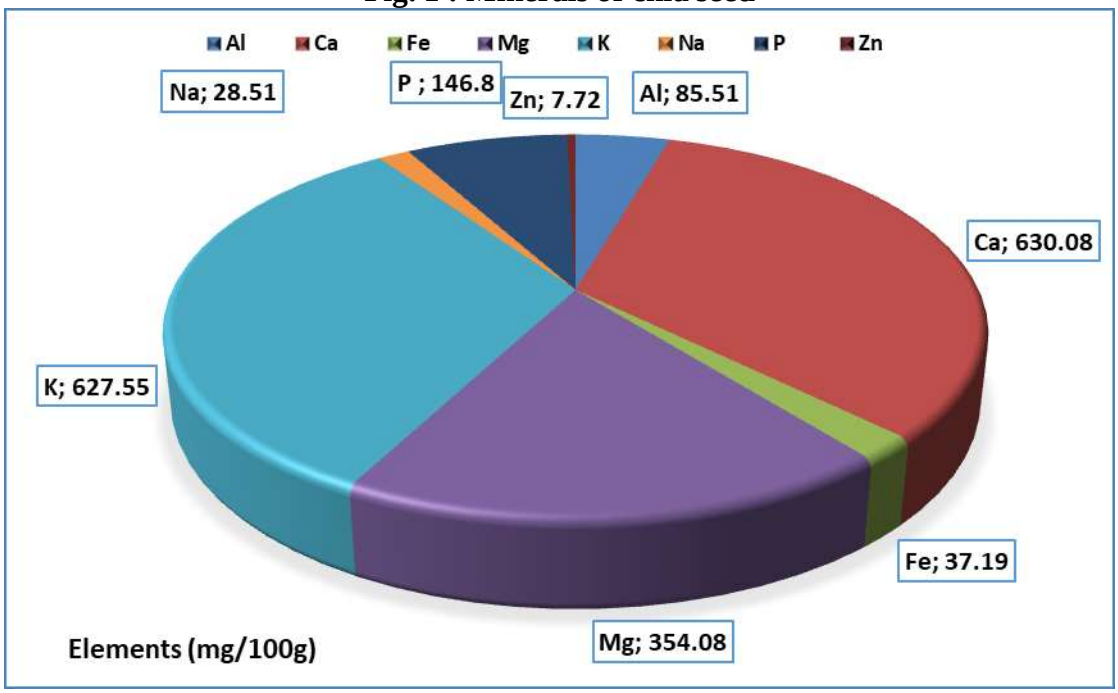
The data in Fig. (1) showed that the minerals of chia seeds contains calcium, potassium, magnesium, phosphorus, aluminum, iron, sodium, and zinc with amounts of 630.08±4.43, 627.55±4.57, 354.08±3.46, 146.80±3.90, 85.51±2.05, 37.19±0.07, 28.51±0.05, 7.72±0.12, mg/100g respectively.

These results are almost in line with those published by **Knez Hrnčič *et al.*, (2019),** who reported that magnesium (335), and calcium (631) were found in the proximate analysis of Chia seeds (Cs) on a dry weight basis.

A review showed that the mineral of chia seeds contains potassium (659), magnesium (309.6), iron (37.73), and zinc (5.1) **(Anwar *et al.*, 2024).**

According to **Prathyusha *et al.*, (2019)** chia seeds is a great source of minerals that are considered inorganic nutrients essential for the maintenance of life's physicochemical processes.

Fig. 1 : Minerals of chia seed



Biological estimations

Effects of chia seeds on (BWG), (BWG%), (FER), and Feed intake

Data Fig. (2) showed body weight gain, body weight gain percent, feed intake, and feed efficiency ratio.

The positive control group (+ve) showed significant increase in BWG, BWG%, feed intake, and FER compared to negative group (-ve).

The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in weight gain, weight gain percent and FER while the groups showed significant increase in feed intake except

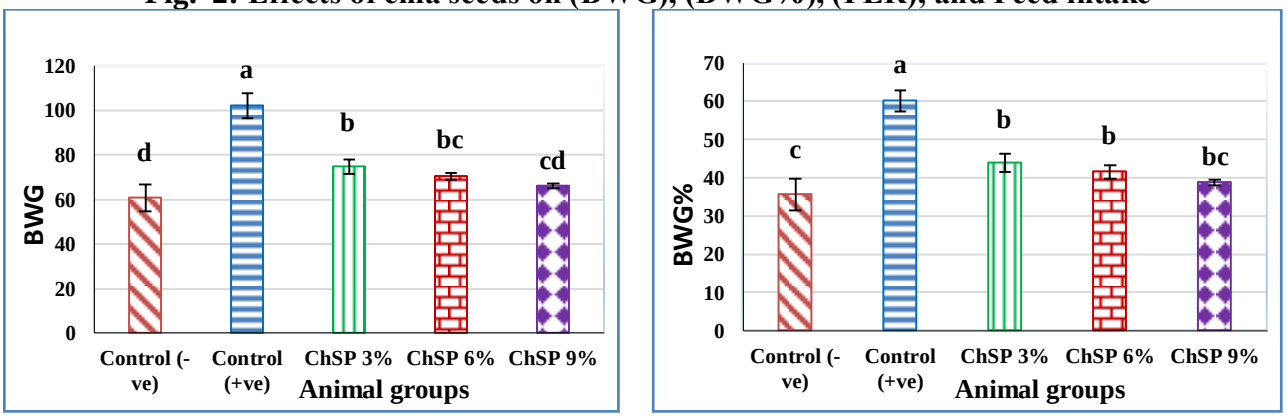
the group treated with chia seeds powder 6% showed non-significant when compared with the control positive group (+ve).

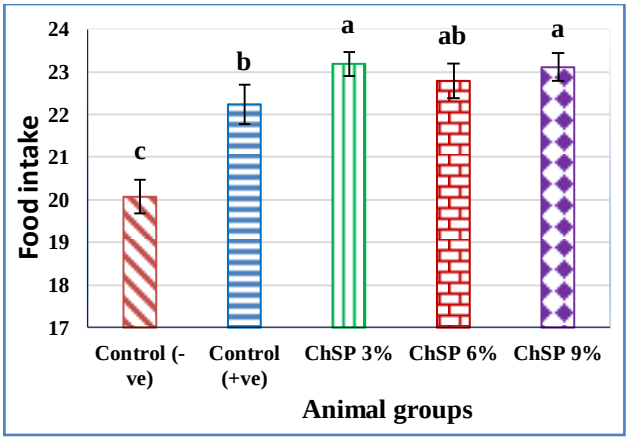
The groups treated with chia seeds powder 3%, and 6% showed significant increase in BWG, BWG%, and food intake while showed non-significant in FER. The group treated with chia seeds powder 9% showed non-significant in BWG, BWG% and FER and showed significant increase in feed intake when compared with the control negative group (-ve).

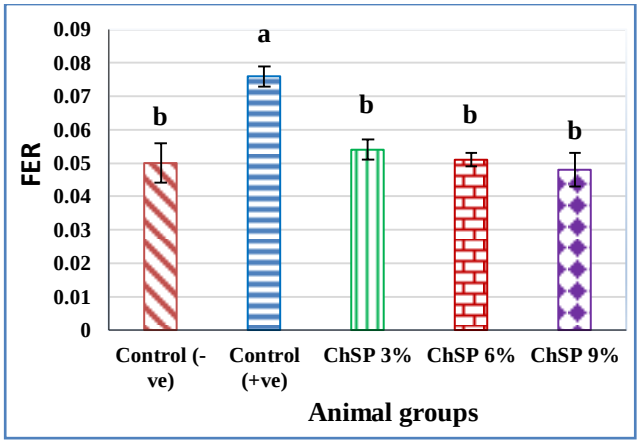
The best value of BWG at group treated with chia seeds 9% at (66.00) followed by, 6% at (70.33) followed by, 3% (74.67 g/ml) respectively.

The best value of BWG% at group treated with chia seeds 9% at (38.75%) followed by, 6% at (41.56%) followed by, 3% (43.86%) respectively.
The best value of feed intake at group treated with chia seeds 6% at (22.79) followed by, 9% at (23.11) followed by, 3% (23.19g/ml) respectively.
The best value of FER at group treated with chia seeds 9% at (0.048) followed by, 6% at (0.051) followed by, 3% (0.054g/ml) respectively.
Mihafu *et al.*, (2020) found that administration of ground chia seeds decreased weight in experimental groups, hence chia seeds might be considering potential choice for weight loss. Chia seeds with a high viscosity and high fiber content can cause the gastrointestinal tract to gel. **(Capitani *et al.*, 2012)** and it maybe act as food additives for feeling satiety, as demonstrated by **Vuksan *et al.*, (2010).**
On the flip side, the high omega-3 concentration of chia seeds can help lower obesity by decreasing fat deposition, increasing lipid oxidation and energy expenditure, and suppressing hunger **(Buckley and Howe, 2010).** Another research found a minor but significant decrease in body weight in rats **(Fernández-Martínez *et al.*, 2019)**
These results are consistent with those of **(Pai and Prabhu (2019),** who found that consuming fiber increases satiety, which in turn decreases excess food consumption and promotes weight reduction. Research by **Quaresma *et al.* (2023)** shows that both of the chia groups had significant decreased waist circumference, weight, and body mass index but non-significant between the experiment and control negative group.
According to **Roy *et al.*, (2022),** chia is generally high source of sterols, fatty acids, phenolic, and dietary fiber, which have proven the potential to optimize metabolism, induce satiety, promote anti-obesity, and utilized as nutritional therapy for several chronic degenerative.

Fig. 2: Effects of chia seeds on (BWG), (BWG%), (FER), and Feed intake







Effects of chia seeds on kidney function

Data in Fig. (3) showed kidney function urea, uric acid and creatinine.

The positive control group (+ve) showed significant increase in urea, uric acid and creatinine compared to negative group (-ve).

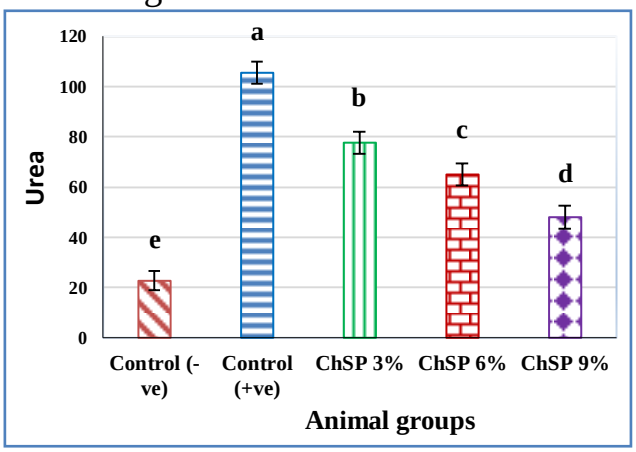
The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in urea at (77.67, 65.00 and 48.00mg/dl) respectively and uric acid at (2.86, 2.59 and 2.16 mg/dl) respectively and creatinine at (1.29, 1.03 and 0.82 mg/dl) compared with the control positive group (+ve).

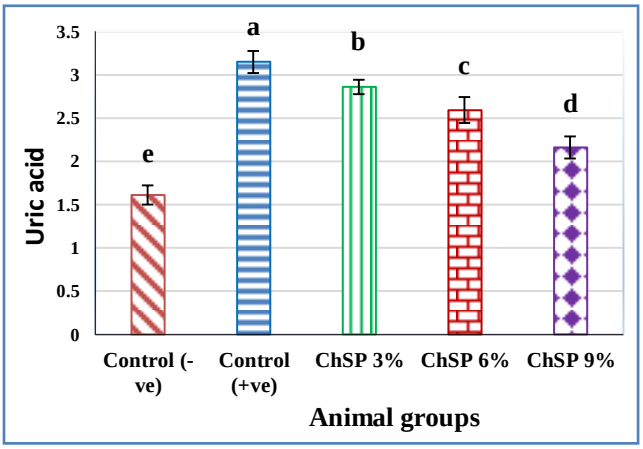
The groups treated with chia seeds powder 3%, 6%, and 9% showed significant increase in urea, uric acid and creatinine compared with the control negative group (-ve).

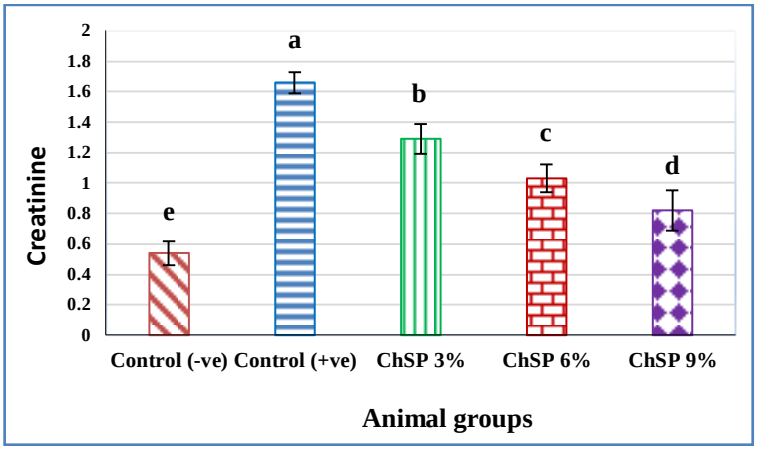
This study's results nearly agree with **Khafagy & Samir (2022)** demonstrated a significant decrease in the levels of urea and creatinine.

This result is due to the chia seeds' strong antioxidant activity and high dietary fiber content. This finding is in agreement with **Fayez *et al* ., 2014** who showed that treatment with chia seeds at different levels of concentration caused a significant decrease in urea, uric acid and creatinine levels compared to positive control group, this effect due to the high content of omega 3 which possesses a protective effect against renal dysfunction in rats.

Fig. 3: Effects of chia seeds on urea, uric acid and creatinine







Effects of chia seeds on liver function

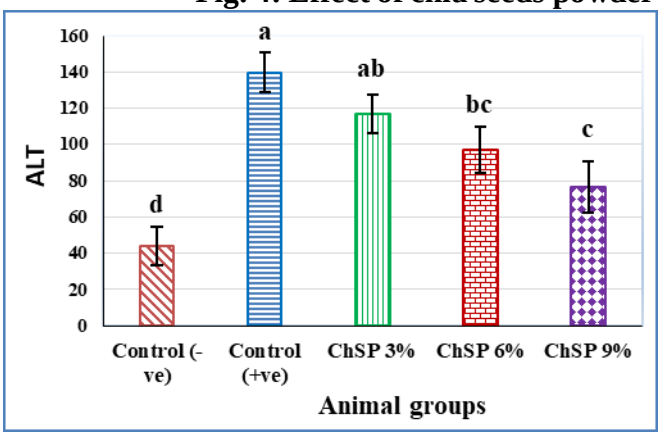
Fig. (4) showed that ALT, AST and ALP in liver.

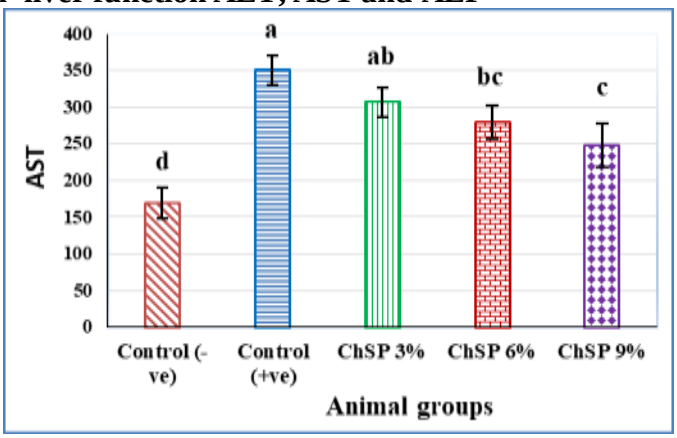
The positive control group (+ve) showed significant increase in ALT, AST and ALP compared to negative group (-ve). The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in ALT at (97.00 and 76.67u/l) respectively and AST at (279.33 and 247.67u/l) respectively and ALP at (375.67, 313.33 and 242.33u/l) respectively, expect the groups treated with chia seeds powder 3% in ALT at (116.67)and AST 3% at (307.00 u/l) showed non- significant compared with the control positive group (+ve).

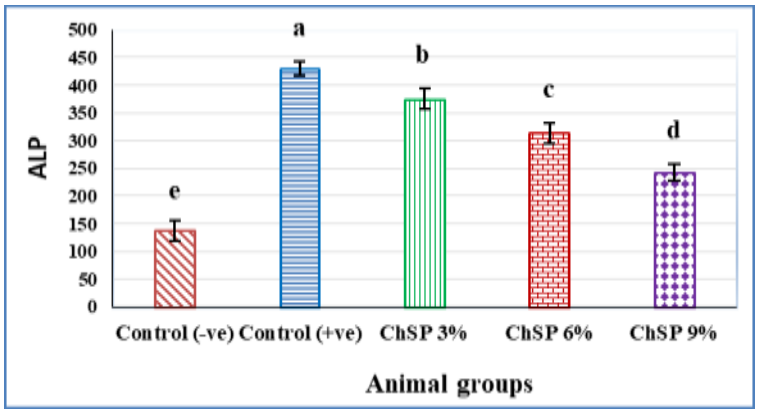
The groups treated with chia seeds powder 3%, 6%, and 9% showed significant increase in ALT, AST and ALP compared with the control negative group (-ve)

Fernandez-Martinez *et al.*, (2019) shown that the high concentration of αlinolenic acid (omega-3), fiber, protein, and phenolic substance in chia may be linked to its hepatoprotective and hypolipidemic benefits. **Ali *et al.*, (2019); Fernández *et al.*, (2019) and Refaat (2021)** reported that chia seed treatment might decrease liver enzymatic activity while marginally improving liver function.

Fig. 4: Effect of chia seeds powder on liver function ALT, AST and ALP







Effects of chia seeds on lipid profile

Data in fig. (5) showed lipid profile CH, TG, HDL, LDL and VLDL.

The positive control group (+ve) showed significant increase in CH, TG, LDL and VLDL while showed significant decrease in HDL compared to negative group (-ve).

The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in CH, TG, LDL and VLDL while showed significant increase in HDL compared with the control positive group (+ve).

The groups treated with chia seeds powder 3%, 6%, and 9% showed significant increase in CH, TG, LDL and VLDL while the groups showed significant decrease in HDL except the groups treated with chia seeds powder 6%, and 9% showed non-significant compared with the control negative group (-ve).

The best value of CH at group treated with chia seeds 9% at (96.67) followed by, 6% at (111.33) followed by, 3% (122.77mg/dl) respectively.

The best value of TG at group treated with chia seeds 9% at (132.33) followed by, 6% at (165.33) followed by, 3% (195.33mg/dl) respectively.

The best value of HDL at group treated with chia seeds 3% at (42.67) followed by, 6% at (47.00) followed by, 3% (51.67mg/dl) respectively.

The best value of LDL at group treated with chia seeds 9% at (18.33) followed by, 6% at (31.33) followed by, 3% (41.00mg/dl) respectively.

The best value of VLDL at group treated with chia seeds 9% at (26.67) followed by, 6% at (36.33) followed by, 3% (39.00 mg/dl) respectively.

Chia seeds are high in omega-3 fatty acids, accounting for approximately 65% of the oil content. Omega-3 fatty acids have been connected to several physiological functions in the human body. Chia

seeds have the potential to be a good source of antioxidants with increased concentrations of healthy unsaturated fatty acids, gluten-free protein, vitamins, minerals, and phenolic compounds. Omega-3 fatty acids are also a great source of dietary fiber, which is excellent for the digestive system and regulating diabetes mellitus and obesity. Chia seed has anti-diabetic, anti-lipidemic, and antioxidant effects.

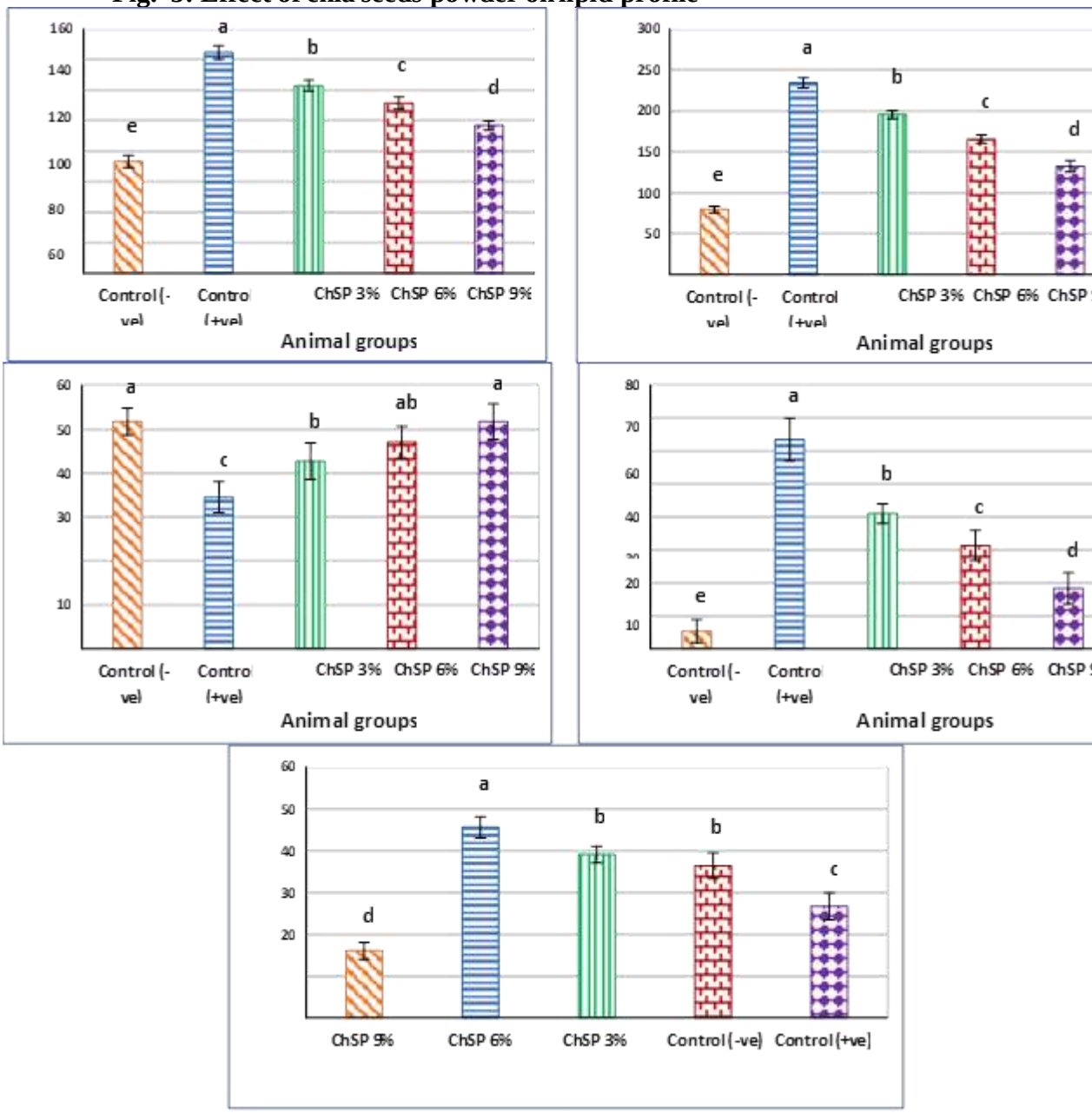
These results nearly agree with **Alagawany *et al.*, 2019 and Alagawany *et al.*, 2020** who discovered a decrease in the treatment group's blood triglyceride levels after taking chia seeds powder. The existence of omega-3 and omega-6 fatty acids as well as the action of chia's natural antioxidants may be responsible for this decrease.

Groups treated with chia seeds powder decreased the cholesterol and LDL levels, which is in agreement with the results of **(Ahmed 2019 and Alagawany *et al.*, 2020).**

According to **Ayerza and Coates (2005); Mahfouz (2020) and Khafagy and Samir (2022)** Triacylglycerol and LDL cholesterol levels significantly decreased in groups treated with chia seed powder, while HDL cholesterol levels increased in rat serum. In addition, these research findings imply that Alpha-linolenic acid in chia seed may be an alternate source of omega-3 for vegetarians and persons allergic to fish and fish products.

Because HDL and LDL molecules are the main carriers of cholesterol from its site of synthesis, the liver, to the body tissues, and because they subsequently reduce the amount of cholesterol and triglycerides available for tissue metabolism, lipogenesis in the liver, and fat accumulation in rats, this reduction confirmed the decrease cholesterol levels observed in this study **(Alvarenga *et al.* 2011).**

Fig. 5: Effect of chia seeds powder on lipid profile



Effects of chia seeds on anti-oxidant catalase (CAT), superoxide dismutase (SOD) and free radical malondialdehyde (MDA)

In fig. (6). The group (+ve) showed significant increase in MDA while showed significant decrease in CAT and SOD compared to negative group (-ve).

The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in MDA while the groups showed significant increase in CAT and SOD compared with the group (+ve).

The groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in CAT and SOD while the groups showed significant increase in MDA compared with the group (-ve).

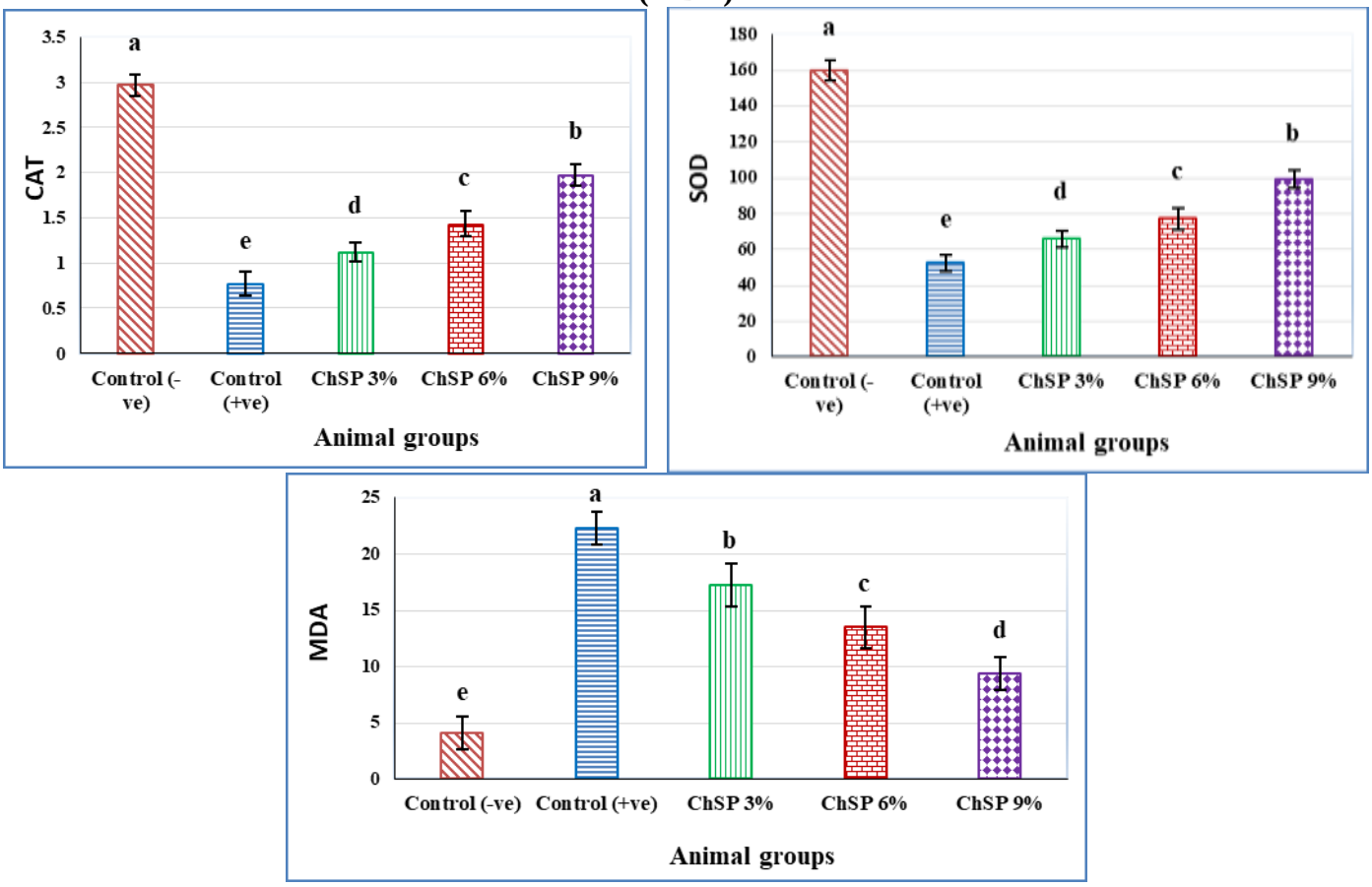
The best value of CAT at group treated with chia seeds 3% at (1.12) followed by, 6% at (1.43) followed by, 9% (1.97u/l) respectively.

The best value of SOD at group treated with chia seeds 3% at (65.67) followed by, 6% at (77.33) followed by, 9% (99.33u/l) respectively.

The best value of MDA at group treated with chia seeds 9% at (9.37) followed by, 6% at (13.47) followed by, 3% (17.20nmol/ml) respectively.

These results agree with **El-Feky *et al.*, (2022),** who discovered that rats given chia seeds had a significant decrease in lipid peroxidation (MDA) and an increase in antioxidant indices such as SOD and CAT activity in the serum. Seed powder antioxidant activity is attributed to the presence of bioactive components such as phenolics and flavonoids, which have a scavenging action on free radicals.

Fig. 4: Effect of chia seeds powder on anti-oxidant (SOD), (CAT) and free radical (MDA)



Effect of chia seeds powder on serum glucose and insulin levels

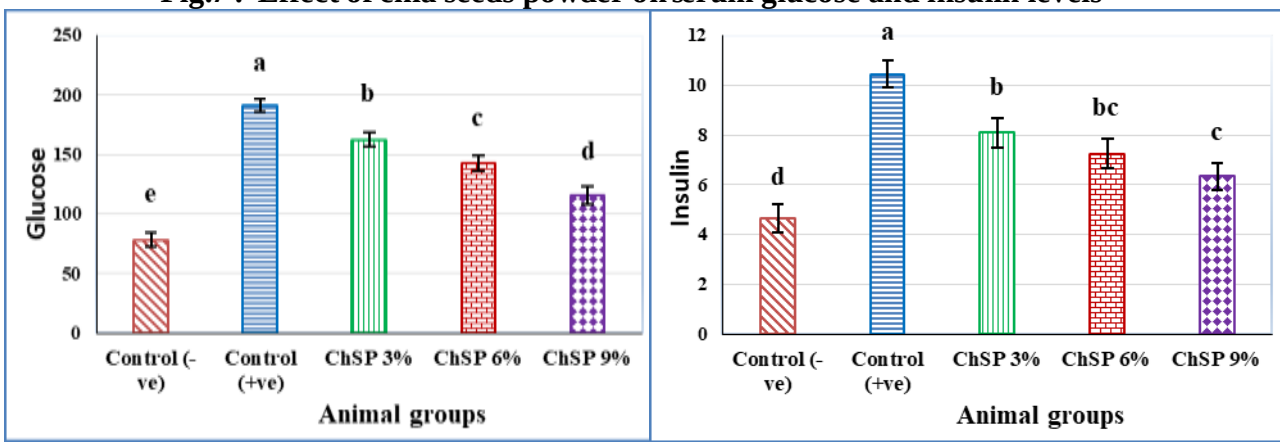
In fig. (7). The group (+ve) showed significant increase in glucose and insulin compared to control negative group (- ve), while the groups treated with chia seeds powder 3%, 6%, and 9% showed significant decrease in glucose at (162.67,142.67 and 115.67) respectively and insulin

at (8.10,7.26 and 6.34) respectively compared with the group (+ve). While showed significant increase compared with the group (-ve).

This result confirming the studies of **(Lamont *et al.*, 2016),** who determined that providing a high-fat diet reduced rats ability to tolerate glucose in the group (+ve)

The acquired data supported the findings of **(Alamri, 2019),** who found that by raising insulin sensitivity and glucose tolerance in obese rats, chia seeds can help lower blood glucose levels in rats. This hypoglycemic impact may be caused by the presence of soluble fiber, which could improve glycemic profiles **(Tamargo *et al.*, 2020).**

Fig.7 : Effect of chia seeds powder on serum glucose and insulin levels



CONCLUSION

In conclusion, we recommend including chia seed in diets for those who exposed to obesity and osteoporosis because they have the ability to reducing weight, reducing fat, and increasing calcium and minerals in the body to avoid osteoporosis. This proves the maximization of the benefit from chia seeds powder and using it in safe doses.

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