Available online www.ijpras.com

International Journal of Pharmaceutical Research & Allied Sciences, 2019, 8(3):131-136

Research Article

ISSN : 2277-3657
CODEN(USA) : IJPRPM

The Influence of Two Types of Chia Seed on Some Physiological Parameters in Diabetic Rats

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ABSTRACT

Chia seeds have been the focus of recent research; however, there are no studies available in the literature that compare the potentially different effects of black chia seeds and white chia seeds on diabetes. Therefore, the current study aimed to compare the effect of black chia seeds and white chia seeds on some selected parameters in diabetic rats. A total of 40 adult male albino Sprague Dawley rats were included in the study, and were divided evenly into four groups. Group 1 (non-diabetic control) and group 2 (diabetic control) were fed a basal diet, group 3 (diabetic) was fed a basal diet plus 20% of black chia seeds, and group 4 (diabetic) was fed a basal diet plus 20% of white chia seeds. Diabetes was induced by a single dose of streptozotocin (60 mg/kg body weight). The results showed that, compared to the control groups, the groups fed with white or black chia seeds had significantly lower levels of fasting blood glucose, total cholesterol, triglycerides, low-density lipoprotein, and liver enzymes (aspartate aminotransferase (AST) and alanine aminotransferase (ALT)), and significantly higher levels of high-density lipoprotein cholesterol. However, no significant difference was detected between black and white chia seeds. In conclusion, black and white chia seeds were both effective in reducing the levels of fasting blood glucose, improving lipid profile, and liver function, and therefore may be able to improve public health.

Key words: *diabetes, chia seeds, rats, blood glucose, lipid profile, liver enzymes.*

INTRODUCTION

Diabetes mellitus is a health problem that is affecting increasing numbers of people. In 2000, there were approximately 171 million diabetic people worldwide; however, by 2011 the number had increased to over 366 million. Furthermore, this number is expected to rise to more than 552 million by 2030 [1]. The highest prevalence of diabetes has been recorded in the Middle East, particularly Saudi Arabia [1–3]. According to data obtained from the Saudi Arabian Ministry of Health, the number of Saudi nationals diagnosed with diabetes was increased from 0.9 million in 1992 to 2.5 million in 2010 [4]. In 2015, approximately 4660 diabetic patients visited family clinics across Saudi Arabia [4]. A recent review indicated that the prevalence of diabetes mellitus among the Saudi population has been increased dramatically in the last 20 years [5]. It is clear that diabetes is one of the major health problems in the country [6]. The latest statistics show that diabetes costs Saudi Arabia more than $870 million per year, and it therefore requires urgent action, such as nutritional intervention [7].

Chia seeds, the edible seeds of *Salvia hispanica*, have been the focus of recent research due to their potential nutritional value and chemical composition [8]. They contain high quantities of dietary fiber, minerals, proteins, and essential fatty acids such as linolenic acid; recently, chia seeds have been recognized as the best source of omega-3 (*n*-3) fatty acid [9–13]. They additionally have a high content of bioactive components, such as tocopherols and phenolic compounds [14–16].

Some studies on rats have revealed that the intake of chia seeds for six and 12 weeks can promote health benefits, such as reduced glucose levels [17]. Another study showed that, compared to the control group, the consumption of chia seeds for 2 weeks led to lower levels of glucose, low-density lipoprotein cholesterol, very low-density lipoprotein, and triglycerides, and higher levels of high-density lipoprotein cholesterol [18].

Another experimental study on rats showed that, compared to the control, chia consumption led to a significant decrease in serum triglycerides content, a three-fold reduction in total cholesterol, and a significant increase in serum HDL cholesterol content [19]. Both ground chia seeds and whole chia seeds showed a positive effect on the lipid profiles of the rats after 30 days of consumption [20]. Additionally, chia seeds were effective in reducing markers of liver damage by reducing the levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) [17, 18]. However, no studies have compared the effect of black and white chia seeds on glucose level, lipid profiles, and liver function in diabetic rats. Therefore, the present study aims to compare the effects of these two types of chia seeds on diabetic rats.

METHODS:

Experimental animals:

The study was conducted in November–December 2018. Adult male albino Sprague Dawley rats weighing between 180–200 g and aged six months were obtained from the Animal Health Research Institute. The rats were kept in well-ventilated cages. The room temperature was controlled and maintained at 23 ± 1 °C, relative humidity was 55–66%, and 12 hour light,12 hour dark cycles were maintained. The rats were fed with normal commercial chow and water *ad libitum*. The study was carried out according to international ethical guidelines for the care of laboratory animals.

Induction of Diabetes:

The experimental animals were fasted for 12 h and then diabetes was induced in rats by a single intraperitoneal injection of a freshly prepared solution of streptozotocin (STZ) (60 mg/kg body weight) in physiological saline. If the blood glucose of animals was more than 277 mg/dL, the animals were considered diabetic.

Experimental procedures:

A total of 40 rats were used in the present study. The rats were divided randomly into four groups of 10 rats: Group 1 was the normal control group (non-diabetic), and received the standard diet; Group 2 was the diabetic control group, and received the standard diet; Group 3 was a diabetic group which received the standard diet plus 20% black chia seeds; and Group 4 was a diabetic group which received the standard diet plus 20% white chia seeds. The rats were fed for six weeks. The rats were weighed at the beginning and end of the experiment (i.e., after six weeks) using a digital balance during the morning. Blood samples were collected from the rats after a 12 hour fast, and water was not restricted. Blood samples were taken at three times—at baseline, after streptozotocin injection to confirm diabetes, and at the end of the experiment.

Statistical analysis:

In the study, the SPSS (version 23.0) program was used to analyze the data. The results are presented as the mean value +/- SD. Statistical comparison was performed using ANOVA to determine the differences between groups.

RESULTS AND DISCUSSION:

The effects of black and white chia seeds on the body weights of diabetic rats are summarized in Table 1. There were no significant differences in initial weight among the groups. However, at the end of the sixth week, the diabetic control group had lost a significant amount of weight due to STZ toxicity. The rats fed with both white and black chia seeds gained a significant amount of weight compared to the non-diabetic and diabetic control groups. However, there was no significant difference in the weight gain detected between the two chia seed groups.

Although no previous studies are comparable to the current study, one previous study showed that the consumption of one type of chia seed for two weeks did not lead to weight loss in rats [18]. Another study showed that the consumption of black chia seeds for six weeks did not reduce the weight gain of rats [17, 18, 20–27]. Additionally, Oliva et al. found that the body weight of diabetic rats did not change after three months of white chia seed intake, and that after six months of white chia seed intake, the rats' body weight was slightly lower than, but not significantly different from the control group [22]. Similar results were reported by Adriana et al. [21]. Another study found that the long-term (13 months) consumption of black chia leads to a significant increase in the body weight of rats [23]. Agustina et al. also confirmed that short-term chia consumption (three months) led to a significant increase in the body weight of rats [26]. The increase in the weight of the rats could be due to the lower digestibility of chia protein, among other factors [18]. Moreover, the high soluble fiber

content of chia seeds may have improved the period of food digestion as well as the absorption of nutrients by intestinal cells. The characteristics of soluble fiber, including its physical and chemical characteristics, may alter the absorption of food nutrients, for example by affecting water-holding capacity, bulking and binding ability, solubility, fermentation, viscosity, and gel formation [24].

Table 1. The effect of the intake of black and white chia seeds on the body weights of diabetic and non-diabetic rats

Rat groups	Body Weight (g)		
	Baseline	Final	Body weight gain (BWG, %)
Non-diabetic control	213.33 ± 10.78	218.31 ± 9.55	2
Diabetic control	232.67 ± 7.37	188.67 ± 7.54	19-
Diabetic rats + black chia seeds	215.24 ± 10.86	288.44 ± 9.12*	34
Diabetic rats + white chia seeds	214.15 ± 8.86	286.54 ± 10.27*	33

The results are expressed as mean ± SE. * Indicates that body weight was significantly higher compared to the control groups ($P<0.05$). There were 10 animals in each treatment group.

The rats' fasting blood glucose levels are summarized in Table 2. At baseline, the fasting blood glucose levels were not significantly different between the groups. However, after chia intake, the fasting blood glucose levels were significantly lower in both the black and white chia seed groups compared to the non-diabetic and diabetic control groups. However, there were no significant differences in fasting blood glucose levels between the black and white chia seed groups. A study by Bárbara (2016) demonstrated that the rats fed with a single type of chia seed had lower blood glucose levels compared to the control group [18]. Additionally, a significant decrease in blood glucose levels was detected in insulin-resistant rats fed with black chia seeds (produced by Salba Smart Natural Products, LLC, Littleton, CO) for three months [26]. Furthermore, another study found that the intake of white chia seeds for six and 12 weeks reduced the blood glucose level of rats [17]. Similar results were reported by Oliva et al. [22]. Additionally, a study in humans showed that incorporating chia seeds into bread led to a significant reduction in theblood glucose level of the patients [28]. This could be due to the high level of dietary fiber in chia seeds [9, 10, 18]. The fiber content of chia seeds has been found to be higher than that of wheat, oats, corn, and rice by 2.3, 2.6, 8.3, and 9.8 times, respectively [29]. It is known that the viscosity of the intestinal lumen can be increased by the consumption of soluble dietary fiber, which can decrease the absorption of glucose due to the reduction in the contact between glucose and the enterocyte [25].

Table 2. The effect of the intake of black and white chia seeds on the fasting blood glucose levels of diabetic and non-diabetic rats

Rat groups	Fasting blood glucose level (mg/dl)		
	Baseline	Diabetes induction	Final
Non-diabetic control	70 ± 1.58	----------	72 ± 1.55
Diabetic control	72 ± 2.1	411.70 ± 39.80	390 ± 11
Diabetic rats + black chia seeds	71 ± 1.2	415.66 ± 40.55	210 ± 30*
Diabetic rats + white chia seeds	70 ± 1.6	417.75 ± 39.45	213 ± 28*

The results are expressed as mean ± SE. * Values are significantly different ($P<0.05$) compared with the control groups. There were 10 animals in each treatment group.

Tables 3 and 4 depict the levels of serum total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), ALT, and AST. The levels of TC, TG, LDL, ALT, and AST were significantly lower in both chia seed groups compared to both control groups. Additionally, the levels of HDL were significantly higher in the chia seed groups than the control groups. However, there were no significant differences between HDL levels in the black and white chia seed groups. A study by Silva et al. showed that, compared to the control group, the consumption of black chia seeds for two weeks led to lower concentrations of triacylglycerides, low-density lipoprotein cholesterol, ALT, and AST, and higher concentrations of high-density lipoprotein cholesterol [18]. Another study reported that TG levels were decreased, and HDL content was increased significantly, in the rats fed with a diet including 15% chia seeds

[19]. The consumption of both black ground chia seeds and whole black chia seeds showed a positive effect on the lipid profiles of rats after 30 days of consumption [20]. Another study found that, compared to the control groups, the levels of TG were significantly lower in the rats fed with chia seeds for three weeks [22]. Additionally, the consumption of white chia seeds was found to be effective for reducing liver damage by reducing AST and ALT levels [17]. An improvement in lipid profiles and liver function has been observed following the consumption of both black and white chia seeds, which can be attributed to the high level of omega-3 fatty acids in chia seeds [9–13, 30]. Additionally, some studies have indicated that dietary omega-3 fatty acids reduce the plasma levels of triglycerides [31].

Another substance that has been found to improve both lipids and liver enzymes is a-linolenic acid. This substance is present at high levels in chia seeds, ranging from 14 to 20 g/100 g (55 to 65.8%) [29]. Caffeic acid and chlorogenic acid are the main antioxidants in chia seeds, and can inhibit lipid peroxidation. These substances have been shown to be significantly stronger and more effective than other antioxidants such as vitamin E and vitamin C [32]. Another antioxidant which is present in chia seeds is quercetin, which can prevent the oxidation of lipids. Additionally, the antioxidant properties of quercetin are considered to be stronger than those of some flavonol compounds [33].

Table 3. The effect of the intake of black and white chia seeds on the serum lipid profiles of diabetic and non-diabetic rats

Rat groups	Serum lipid profile (mg/dl)			
	TC	TG	HDL	LDL
Non-diabetic control	63.38 ± 3.12	56.55 ± 5.28	18.37 ± 0.48	30.62 ± 0.55
Diabetic control	103.78 ± 2.15	152.41 ± 6.53	14.45 ± 0.51	55.16 ± 1.38
Diabetic rats + black chia seeds	77.54 ± 2.63	90.69 ± 1.38	19.11 ± 0.18	40.88 ± 2.43
Diabetic rats + white chia seeds	78.44 ± 2.55	88.70 ± 1.33	20.12 ± 0.21	41.86 ± 2.39

The results are presented the mean ± SE. * Values are significantly different from the control groups ($P<0.05$). There were 10 animals in each treatment group.

Table 4. The effects of the intake of black and white chia seeds on liver markers in diabetic and non-diabetic rats

Rat groups	Black chia seeds	
	ALT (U/L)	AST (U/L)
Non-diabetic control	47.10 ± 2.16	95.50 ± 2.91
Diabetic control	107.81 ± 9.93	133.01 ± 8.21
Diabetic rats + black chia seeds	47.00 ± 3.77	86.60 ± 4.62
Diabetic rats + white chia seeds	46.01 ± 3.70	84.55 ± 4.40

The results are presented the mean ± SE. * Values are significantly different from the control groups ($P<0.05$). There were 10 animals in each treatment group.

CONCLUSION:

The results of this study indicate that the consumption of both black and white chia seeds is effective in reducing the levels of fasting blood glucose, total cholesterol, triglycerides, low-density lipoprotein, and liver enzymes (AST and ALT) in rats. Additionally, the levels of high-density lipoprotein cholesterol were significantly higher in both the black and white chia seed groups than in the control groups. However, no significant difference was detected between the two chia seed groups.

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