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An Evaluation of dark sesame seeds versus white sesame on blood glucose, oxidative stress markers, and kidney function in streptozotocin-induced diabetic rats

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Abstract

Sesame seeds have been the focus of recent studies due to their potential nutritional value and chemical composition. Forty-eight albino Sprague Dawley rats were divided into 4 groups (12 rats each in group):Group 1—the normal control group, Group 2—the diabetic control group, Group 3—the diabetic group that received the standard diet+15% dark sesame seeds, and Group 4—the diabetic group that received the standard diet+15% white sesame seeds for 6 weeks. Diabetes was induced by a single dose of streptozotocin (60 mg/kg body weight).The levels of blood glucose, (MDA) malondialdehyde, serum creatinine, urea, and Uric acid were statistically lower in G3 and G4 than in G2 ($P<0.05$). Total antioxidants (TAC) were statistically higher in G3 and G4 than in G2 ($P<0.05$).No significant difference was found between G3 and G4 in blood glucose. However, G3 showed a significant improvement in MDA and TAC, serum creatinine, urea, and uric acidcompared to G4 ($P<0.05$). Consuming both dark and white sesame seeds can improve blood glucose, oxidative stress markers and kidney function in streptozotocin-induced diabetic rats. Therefore, sesame seeds area potential protective natural agent against diabetes complications.

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Introduction

Diabetes mellitus is defined as a group of metabolic disorders that lead to an increase in blood glucose levels over a long period (WHO, 2008). By 2030, it is expected that the number of diabetics will reach 370,000,000 people worldwide (Bommer *et al*, 2018). A recent review indicated that diabetes prevalence reached alarming rates in Saudi Arabia (Alotaibi *et al*, 2017). Oxidation agents and inflammatory mediators increase by elevating the level of blood glucose (Yuan *et al*, 2019).

These two factors increase the development of nephropathy, retinopathy, cardiovascular disease, and neuropathy (Semeraro *et al*, 2015). It was found that hyperglycemia results in oxidative stress, which can cause damage to peripheral tissues and lead to the secondary complications of diabetes (Pizzino *et al*, 2017). Thus, diabetes mellitus requires therapeutic strategies to help reduce theside complications of diabetes with fewer adverse effects, such as using herbal remedies (Pandey *et al*, 2011).

One of the medicinal plants used widely in Saudi Arabia and other Middle Eastern countries is sesame seeds (Mohammed *et al*, 2018). These seeds are extremely rich with a wide range of bioactive components, such as polyphenols, phytosterols, tocopherols, and flavonoids. In addition to these compounds, sesame seeds arerich with phenolic lignans, sesamin, and sesamolin (Mohammed *et al*, 2018). These seeds are an important source of oil, protein, and fatty acids, including oleic, linoleic, palmitic, stearic, and arachidic acids (Bertrand, 2018). Both dark and white sesame were shown to be good sources of proteins, minerals, and fat. However, the content of Vitamin E, K, and C were significantly higher in white sesame, whereas Vitamin A, B, and carbohydrates were significantly higher in dark seeds. Both types of sesames are important sources of unsaturated fatty acids, such as oleic and linoleic acid, and are the source for saturated fatty acids, including palmitic and stearic acid (Kanu, 2011; Mohammed *et al*, 2011). It was reported that these compounds act as antioxidant, anti-inflammatory, antihypertensive, antimutagenic, antithrombotic, and cardioprotectiveagents (Wan *et al*, 2015; Kaneez *et al*, 2007).

A few studies on animals have shown that the consumption of white sesame oil leadsto a significant reduction in the blood glucose level of diabetic rats (Haidari *et al*, 2016; Aslam *et al*, 2017; Khaneshi *et al*, 2013; GuimarãesI *et al*,2013; Thuy *et al*, 2017). It is well known that diabetes has a negative impact on renal function and oxidative stress (Pecoits *et al*,2016) It was reported that feeding diabetic rats with white sesame oil and sesame butter led to improvements in oxidative stress markers (Haidari *et al*,2016)A review including six clinical trials showed that the consumption of white sesame seeds results in a reduction in oxidative stress markers (Gouveia *et al*,2015). Feeding rats with white sesame oil for 60 days led to a significant reduction in urea, while creatinine levels were increased compared to baseline, and uric acid did not show any significant changes (Aslam *et al*, 2017). On the other hand, another study revealed that white sesames reduced the creatinine levels of rats with acute kidney injury (Dur-Zong *et al*, 2011). White sesame oil can act as a protective agent by reducing both the urea and creatinine of rat kidneys injected with cypermethrin (Abdou *et al*, 2012). However, none of these studies have evaluated the influence of dark sesame seeds on blood glucose, oxidative stress markers, and kidney function. Therefore, the current study sought to investigate the impact of black sesame seeds on blood glucose andoxidative stress markers likekidney functions and compare themto those of white sesame seeds in Streptozotocin-Induced Diabetic Rats.

Materials and methods

Experimental animals

In total, 48 male albino Sprague Dawley rats (body weight 190–210 g, age 7–8 weeks) were picked up from the Animal Health Research Institute. The rats were kept in well-ventilated cages and maintained under standard laboratory conditions (24 ± 1 °C) with a 12 h light/12 h dark cycle and55±10 %humidity. The rats had unrestricted access to water, and they were fed with a normal commercial diet.The study was carried out according to international ethical guidelines for the care of laboratory animals.

Induction of diabetes

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 after the experimental animals were fasted for 12 hours. If the blood glucose of the animals was more than 277 mg/dL, the animals were considered diabetic.

Experimental procedures

After the acclimatization period,the rats were divided randomly into four groups of 12 rats each:

Group 1(G1): The normal control group (healthy group), which received the standard diet.

Group 2 (G2): The diabetic control group, which received the standard diet.

Group 3 (G3): The diabetic group which received the standard diet plus 15% dark sesame seeds for 7 weeks.
Group 4 (G4): The diabetic group, which received the standard diet plus 15% white sesame seeds for 7 weeks.

Both dark and white sesame were purchased from a local market. After a 12 hour fast (except for water), Blood samples were collected from the rats to measure Serum glucose, malondialdehyde(MDA), total antioxidant capacity(TAC), Serum creatinine, urea, and Uric acid.Blood samples were collected at three times—at baseline, after streptozotocin injection to confirm diabetes, and at the end of the experiment.

Statistical analysis

IBM SPSS for Windows, version 23 (IBM Corp., Armonk, N.Y., USA) was used to analyse the data. The results are presented as the mean value +/- SD. The statistical comparison was performed using ANOVA to determine the differences between the groups. Differences were considered to be statistically significant at P<0.05.

Results

The mean levels of fasting blood glucose at the end of the study are presented in Table 1. Prior to treatment, there were no significant differences in the level of fasting blood glucose between the groups. After injection of Streptozotocin, the level of fasting blood glucose was significantly elevated (P=0.01).

However, after treatment, the level of fasting blood glucose was significantly lower in diabetic rats treated with dark sesame (P=0.02) and white sesame (P=0.01) compared to the diabetic control. No significant difference was detected between the diabetic rats treated with dark or white sesame.

Table 1. Effect of dark and white sesame seeds consumption on serum glucose levels in Diabetic Rats.

Rats groups	Prior treatment	Diabetes induction	After treatment
Normal control	73 ± 1.49	-----------	72 ± 1.55
Diabetic control	71 ± 2.3	412.71 ± 38.81	399 ± 11.23
Diabetic rats treated with dark sesame	72 ± 1.4	414.66 ± 40.73	210 ± 30.12*
Diabetic rats treated with white sesame	71 ± 1.7	418.75 ± 39.53	218 ± 28.17*

The results are expressed as the mean ± standard error. * Values are significantly different (P<0.05) compared with the diabetic control groups.

The levels of TAC and MDA are depicted in Table 2. At the end of the study, the level of MDA was significantly higher in the diabetic control compared to the normal group (P=0.02).

The oral intake of dark and white sesame seeds led to a significant reduction in MDA concentrations in G3 and G4 at the end of the treatment period compared to G2 (P=0.03). However, G3 showed a statistically lower level of MDA than G4 (P=0.04).

The level of TAC in G2was statistically lower than that inG1 (P=0.04). Following the treatment, there was a significant increase in the TAC level in G3 and G4 compared to G2 (P=0.01). The TAC concentration in G3 was statistically higher compared to that in G4.

Data are expressed as the mean±SD:(MDA) malondialdehyde; (TAC)total antioxidant capacity.* Values are significantly different from G2 (P<0.05). †Values are significantly different from G3 (P<0.05). The results of the effects of dark and white sesame seeds on Serum creatinine, urea, and uric acidare presented in Table 3. There was a more significant reduction in these three parameters in G3 and G4 compared to G2 (p=0.03).However, the Serum creatinine, urea, and uric acidin G3 were statistically lower than those in G4.

Table 2. The influence of dark and white sesame on the malondialdehyde (MDA) and total antioxidant (TAC) levels in the serum of Diabetic Rats.

Rat groups	MDA (µmol/L)	TAC (µmol/L)
NORMAL control	2.87±0.34	0.55±0.17
Diabetic control	4.21±0.39	0.40±0.05**
Diabetic rats treated with dark sesame	2.69±0.31*	0.90±0.17*
Diabetic rats treated with white sesame	3.66±0.28* †	0.59±0.15* †

Discussion

The present study is a unique in determining the effect of dark sesame seeds versus white sesame seeds on blood glucose, oxidative stress markers, and kidney function. It was found that both white and dark sesame seeds were effective in improving Blood Glucose level, and there was no significant difference between them. These results were in agreement with the previous study, which found that white Sesame oil was effective in reducing the level of blood Glucose in diabetic rats. (Haidari *et al*,2016).Another study conducted by Farhan *et al*. found that feeding rats with 12% white sesame oil led to a reduction in the high Blood Glucose level of diabetic rats (Aslam *et al*,2017). Similar results were also reported elsewhere (Guimarães *et al,* 2013). A recent study analyzed humans with type 2 diabetes who consumed white sesame oil for 3 months. The results showed a decrease in both HbA1c and blood glucose level at the end of the treatment (Aslam *et al*, 2019). The improvement in blood glucose level when consuming sesame seeds or oil could be attributed to the great amount of bioactive components, such as sesamin, fat-soluble lignans, sesamolin, and γ-tocopherol, which could act as anti-diabetic agents (Prakash *et al*, 2019). Furthermore, sesame contains a high quantity of fatty acids, which could regulate sugars by protecting β-cells from death and improving insulin sensitivity (Acosta-Montaño *et al*, 2018). It is also thought that the availability of lignans in sesame is responsible for its multiple physiological properties, including its anti-diabetic properties (Sankar *et al*, 2011).

The present study demonstrated that higher level of glucose are associated with lower TAC. This result indicates a direct correlation between diabetes and oxidative stress. The main mechanisms behind the incidence of oxidative stress biomarkers in case of diabetes are protein glycation, glucose oxidation, polyol pathways, and the formation of advanced glycation end products (Juskiewicz *et al*, 2008). An earlier study found that feeding rats with (0.5 g/kg) white sesame oil and sesame butter elevated TAC and reduced MDA (Haidari *et al*, 2016). A recent study in 2019, conducted among patients with type 2 diabetes, demonstrated that the consumption of white sesame oil led to reduced oxidative stress (Aslam *et al*, 2019). A review conducted for a few clinical trials revealed that the consumption of white sesame seeds results in a reduction in oxidative stress markers (Gouveia *et al*, 2015). The anti-oxidative properties that are available in sesame seeds and its constituent lignans (i.e., sesamin, sesamol, episesamin, and sesamolin) can improve TAC and prevent oxidative stress damage (Juskiewicz *et al*, 2008). It was reported that the intake of (35 g/d) white sesame oil for 14 days significantly increased plasma TAC among patients with hypertension[32].These results agreed with a previous study on rats, which revealed that white sesame oil could lower oxidative stress (Hsu *et al*, 2008). Furthermore, the consumption of 20 mg/kg of white sesame for 7 weeks by diabetic rats attenuated an increase in MDA and lowered the activity of superoxide dismutase (Roghani *et al*, 2013). These results are in accordance with the results of the current study, which found that the consumption of both dark and white sesame seeds reduces the level of MDA and increased TAC.

However, dark sesame seeds were more effective than white sesame seeds in improving MDA and TAC.

Table 3. The effects of dark and white consumption on the Serum creatinine, urea, and Uric acid of Diabetic Rats.

Rat groups	Creatinine (mg/dl)	Urea (mg/dl)	Uric acid
Normal control	0.51 ±0.02	31.88 ±1.39	1.95 ±0.03
Diabetic control	1.25 ±0.04	58.88 ±3.33	2.45 ±0.069
Diabetic rats treated with dark sesame	0.66 ±0.05*	33.08 ±1.67*	1.69 ±0.02*
Diabetic rats treated with white sesame	0.80 ±0.05*†	40.77 ±2.41*†	1.97 ±0.03*†

The results are expressed as the mean ± SE.

* Values are significantly different from G2 ($P<0.05$).

†Values are significantly different from G3 ($P<0.05$).

The availability of dietary lignans in sesame seeds or oils were responsible for protecting the liver against Fe-induced oxidative damage. Further, during oxidative stress, Antioxidant enzymes play an important role as secondary defense mechanisms (Pathak *et al,* 2019). A recent systematic review on the antioxidant activity of Sesame seeds demonstrated that white sesame seeds and oil have potential antioxidant impact in various test systems through various pathways (Afroz *et al*, 2019).

Increasing concentrations of serum urea, creatinine, and uric acid are usually considered to be indications of renal dysfunction (Pandya *et al*, 2019). In the present study, the diabetic group showed a significant increase in these three parameters. After treatment, the experimental groups showed a significant reduction in serum urea, creatinine, and uric acid compared to the diabetic rats. However, the levels of these parameters were significantly lower for rats fed with dark sesame seeds compared to those fed with white seeds. Aslam *et al* (2017). Demonstrated that rats who consumed white sesame oil for 60 days showed a significant decrease in uric acid and Urea, while their creatinine remained fairly stable after treatment. Since uric acid and urea mainly come from protein breakdown, their lower values could be due to the lower overall protein breakdown in the sesame groups. Furthermore, another study found that rats fed with 5 mL/kg of white sesame oil showed improvements in urea and creatinine (Abdou *et al*, 2012). The sesame seed skin contained a high amount of lignans and phenolic compounds, which play an important role in antioxidant effects, which may explain the differences between the dark and white sesame seeds in the mentioned parameters. These findings, together, support the protective role of white and dark sesame seeds against diabetes complications, such as high level of urea, creatinine, uric acid, and MDA. Consuming sesame seeds over time may improve health in those with diabetes.

Conclusion

In conclusion, from the present study, both dark and white sesame were effective in improving the blood glucose, oxidative stress markers, and kidney function of diabetic rats. However, dark sesame was more effective than white sesame seeds. Therefore, sesame seeds are a potential protective natural agent and could be incorporated into a wide range of foods eaten regularly in Saudi Arabia and in other countries.

Conflict of interest

None.

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