

Dietary almonds and peanuts improve metabolic health and reduce oxidative stress in wistar rats

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ABSTRACT

Metabolic syndrome characterized by insulin resistance, atherogenic dyslipidemia, and hypertension, is a significant health concern often associated with obesity and Diabetes Mellitus. Regular consumption of nuts has been suggested to mitigate some of these conditions. This study investigates the effects of almond and peanut consumption on oxidative stress, plasma lipids, body weight, glucose, and blood pressure in Wistar rats. Wistar rats were divided into four dietary groups: standard diet (ST), high-fat diet (HF), high-fat diet with almonds (HFA), and high-fat diet with peanuts (HFP). The treatment lasted for 8 weeks, during which body weight was monitored weekly. Blood pressure measurements and retro-orbital blood samples were collected before and after the treatment. Superoxide dismutase (SOD) and malondialdehyde (MDA) levels were measured using ELISA and TBARS methods. Blood lipid profiles and glucose levels were analyzed using enzymatic methods. Statistical tests used the oAnova followed by Posthoc LSD. The HF group exhibited significant increases in body weight, blood glucose, cholesterol, triglycerides, MDA, and blood pressure, with reduced SOD levels. Conversely, the HFA and HFP groups showed moderated increases in these parameters compared to the HF group. Both nut-supplemented groups had significantly lower MDA levels and higher SOD activity, indicating reduced oxidative stress and enhanced antioxidative defenses. Almonds and peanuts can reduce body fat, improve lipid profiles, and stabilize blood glucose levels, suggesting their potential role in promoting metabolic health and reducing cardiovascular risk. Further research should explore the long-term benefits and the specific bioactive compounds responsible for these effects.

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INTRODUCTION

Metabolic syndrome represents a significant form of metabolic dysregulation characterized by insulin resistance, atherogenic dyslipidemia, central obesity, and hypertension (Fahed et al., 2022; Moe et al., 2024; Saklayen, 2018). Its incidence often coincides with obesity and Type 2 Diabetes Mellitus (T2DM) (Gamba et al., 2023; Ramírez et al., 2023; Saklayen, 2018).

The prevalence of metabolic syndrome has been studied in various populations, revealing a notable burden on public health. For instance, a cross-sectional study on the U.S. adolescent population from 2001 to 2020 reported a prevalence of 2.66% based on household food insecurity status (Messiah et al., 2024). Additionally, the Center for Disease Control and Prevention (CDC) reported in 2017 that approximately 12.2% of the U.S. adult population suffers from T2DM, with about 85% of these patients also experiencing metabolic syndrome, thus elevating their cardiovascular disease risk (Fahed et al., 2022). In Indonesia, the prevalence of metabolic syndrome is 21.66%, with the highest incidence in Jakarta province (Herningtyas & Ng, 2019).

The pathophysiology of metabolic syndrome involves complex mechanisms, many of which are not yet fully understood. Key contributors include lifestyle factors such as overeating and lack of physical activity, which lead to high-calorie intake and visceral adiposity. This adiposity triggers multiple pathways associated with metabolic syndrome (Pekgor et al., 2019). Adipocytes secrete hormones like leptin and decrease adiponectin, impacting the functionality of pancreatic beta cells and leading to insulin resistance (Saklayen, 2018). Insulin, a peptide hormone from pancreatic beta cells, regulates glucose metabolism by inhibiting liver lipolysis and gluconeogenesis and increasing glucose absorption in various tissues (Winn et al., 2024). Insulin resistance disrupts these processes, resulting in increased circulating free fatty acids (FFA), which exacerbate insulin resistance and elevate cholesterol and triglyceride synthesis, contributing to atherogenic dyslipidemia (Fahed et al., 2022; Martin et al., 2020).

Elevated cholesterol levels are a critical risk factor for cardiovascular disease (CVD) due to their role in atherosclerosis formation (Agrawal et al., 2020; Zachariah, 2024). The development of atherosclerosis is driven by reactive oxygen species (ROS) production and lipid oxidation (Barteková et al., 2021; Ellulu et al., 2016; Glenn et al., 2023). Hyperlipidemia, particularly hypercholesterolemia, enhances lipid peroxidation, producing malondialdehyde (MDA), a secondary product under oxidative stress conditions. High MDA concentrations are associated with pathological conditions and vascular damage, contributing to heart disease. LDL particles modified by MDA further exacerbate atherosclerosis (Lankin et al., 2023; Sulaiman & Sangging, 2024).

Almonds and peanuts, widely consumed nuts, are rich in nutritional and bioactive components that offer protective effects against CVD (Gulati et al., 2023). Research comparing diets rich in these nuts versus high-fat diets on health markers such as weight, blood pressure, serum lipid levels, and blood glucose is essential to understand their impact on health (Parilli-Moser et al., 2022). Although numerous studies have highlighted the protective effects of nuts against cardiovascular risk, the evidence about their role in supporting cardiometabolic health remains contentious (Dikariyanto et al., 2020; Gayathri et al., 2023; Nora et al., 2020; Sapp et al., 2022).

This study aims to explore and compare the effects of almond and peanut consumption on various health markers in Wistar rats to determine which dietary pattern offers better health outcomes. By examining these variables, we can gain insights into how different dietary components influence metabolic health and cardiovascular risk factors.

Previous research has highlighted the benefits of nut consumption in reducing body fat and improving lipid profiles. Guarneiri and Cooper (2021) reported that nuts reduce body fat, and Dreher (2021) emphasized almonds' superior nutritional profile compared to other nuts. Liu *et al* (2019) found that nut consumption is linked to a lower risk of weight gain compared to other snacks. The fiber content in nuts delays gastric emptying and suppresses hunger, increasing fatty acid binding in the intestines and enhancing fecal excretion.

Despite the known benefits, research on the effects of almonds and peanuts on specific health markers in the context of metabolic syndrome is limited. Research backs the positive effects of these nuts on blood sugar regulation and lipid levels, respectively (Guasch-Ferré et al., 2023; Hou et al., 2018). However, comprehensive studies comparing the effects of almonds and peanuts on a broad range of metabolic health markers are scarce.

The aim of this study is to assess the effects of almonds and peanut feeding on oxidative stress, plasma lipids, body weight, glucose, and blood pressure in Wistar rats. This research aims to provide a detailed comparison of the effects of these nuts versus high-fat diets, offering new insights into their potential as dietary components for improving metabolic health. The uniqueness of this study is found in its thorough approach to assessing various health indicators, thereby addressing existing research gaps and contributing to the broader understanding of nut consumption's role in managing metabolic syndrome and related conditions.

RESEARCH METHOD

Peanut were obtained from the local market in Yogyakarta and almond produced by CV. Ocean of Eternal Blessings, Surabaya, East Java. Almonds were prepared as a suspension based on a dose reported in the literature (Berryman et al., 2015). The human dose of 150 grams, assuming a body weight of 70 kg, was converted to a rat dose for a body weight of 200 grams, resulting in a dose of 2.7 grams. This suspension contained 1.5093 grams of monounsaturated fatty acids (MUFA). Similarly, peanuts were prepared as a suspension according to the literature (Petersen et al., 2022). The human dose of 70 grams, assuming a body weight of 70 kg, was converted to a rat dose for a body weight of 200 grams, resulting in a dose of 1.26 grams. This suspension contained 0.3078 grams of polyunsaturated fatty acids (PUFA).

Wistar rats were grouped into four groups: Standard diet (ST, normal standard feed), High fat diet (HF, standard feed + 2 ml duck egg yolk), High fat diet with almond (HFA, HF + 2.7 grams almond suspension), and High fat diet with peanut (HFP, HF + 1.26 grams peanut suspension). Rats were treated for 8 weeks. Body weight was measured every 7 days. Blood pressure measurements and retro-orbital blood sample collection were conducted before and after treatment. Blood pressure measurements were performed by the CODA® instrument from Kent Scientific on the rats' tails with the volumetric non-invasive blood pressure system method.

Superoxide dismutase examination was performed using the ELISA method from Biovision (Cat K355-100). Malondialdehyde (MDA) levels were measured using the Thiobarbituric Acid Reactive Substances (TBARS) method. The blood total cholesterol, triglyceride, HDL, and LDL level analysis was conducted using a spectrophotometer with the enzymatic methods CHOD-PAP and blood glucose level using GOD-PAP.

Ethical clearance

The ethical clearance issued by YARSI University number 087/KEP-UY/EA.10/IV/2024.

RESULTS AND DISCUSSIONS

A high-fat diet significantly increases both body weight and blood pressure in Wistar rats. However, the inclusion of almonds or peanuts in the diet appears to mitigate these effects to some extent. Rats on a high-fat diet supplemented with either almonds or peanuts showed less pronounced increases in both body weight and blood pressure compared to those on a high-fat diet alone (Figure 1).

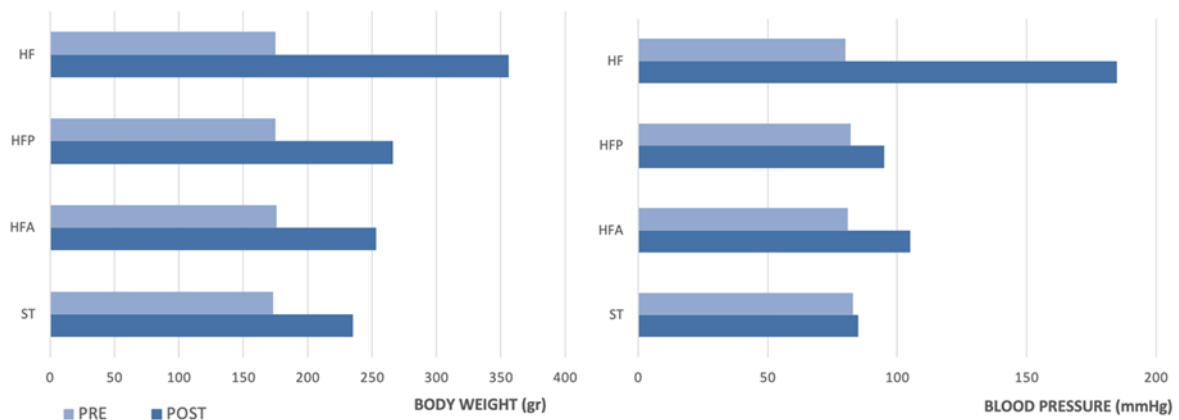


Figure 1. Body weight and blood pressure examination before and after 8 weeks treatment ($p=0.000$, significant level at 95%). (ST: standard diet, HF: high fat diet, HFA: high fat diet with almond, HFP: high fat diet with peanut)

The findings suggest that a high-fat diet significantly increases blood glucose levels in Wistar rats. However, the inclusion of almonds or peanuts in the diet can moderate this increase. The rats on the high-fat diet with almond or peanut supplementation exhibited less pronounced rises in blood glucose levels compared to those on the high-fat diet alone (figure 2).

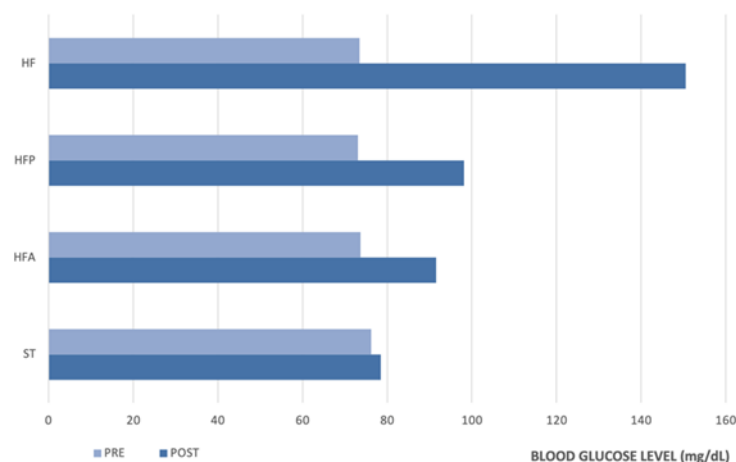


Figure 2. Blood glucose level examination before and after 8 weeks treatment ($p=0.000$, significant level at 95%). (ST: standard diet, HF: high fat diet, HFA: high fat diet with almond, HFP: high fat diet with peanut)

The analysis reveals that a high-fat diet profoundly affects the blood lipid profile of Wistar rats, markedly increasing total cholesterol, triglycerides, and LDL levels, while significantly decreasing HDL levels. In contrast, the inclusion of almonds or peanuts in the high-fat diet appears to moderate these adverse effects. Rats on the high-fat diet with almond or peanut supplementation experienced less severe increases in total cholesterol, triglycerides, and LDL levels, and a less pronounced decrease in HDL levels compared to those on the high-fat diet alone (figure 3).

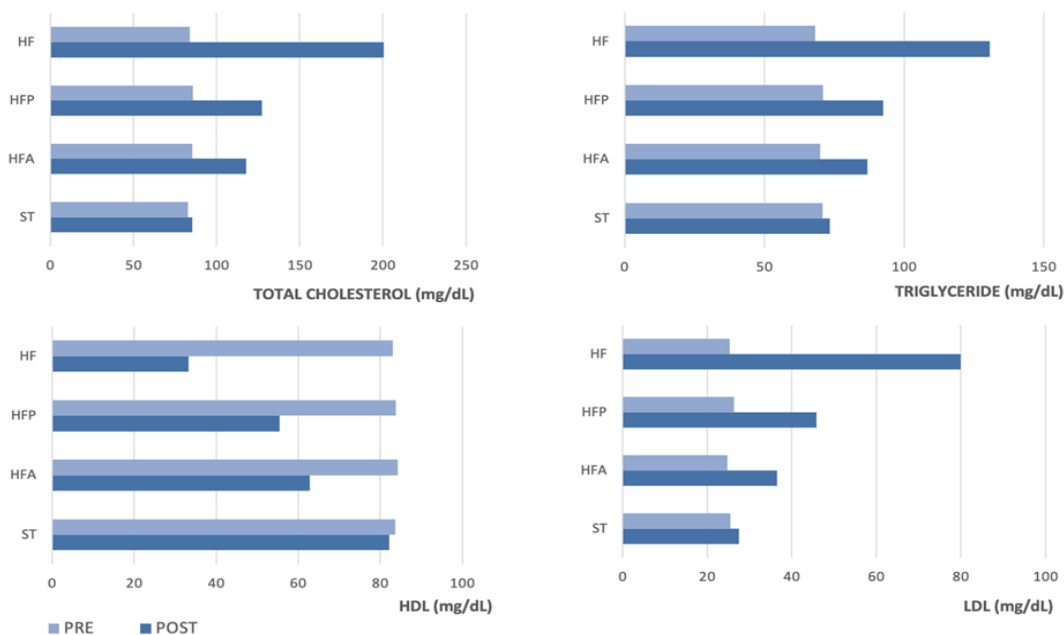


Figure 3. Blood lipid profile examination before and after 8 weeks treatment ($p=0.000$, significant level at 95%). (ST: standard diet, HF: high fat diet, HFA: high fat diet with almond, HFP: high fat diet with peanut)

Supplementation with almonds and peanuts in high-fat diets can significantly reduce oxidative stress, as evidenced by lower MDA levels, and enhance antioxidative defense mechanisms, as indicated by increased SOD levels. Specifically, almonds appear to have a slightly superior effect in reducing oxidative stress and boosting SOD activity compared to peanuts. These findings suggest that incorporating nuts like almonds and peanuts into high-fat diets may mitigate some negative effects of oxidative stress and improve overall antioxidative capacity (figure 4.).

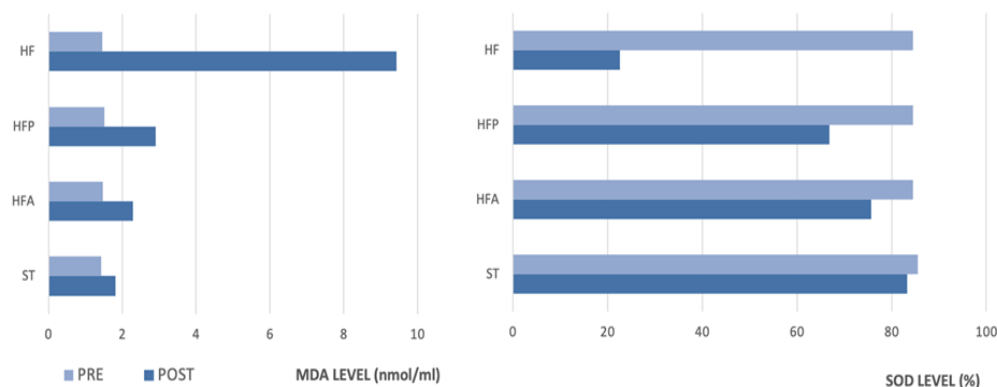


Figure 4. Blood Malondialdehyde (MDA) and Superoxide-dismutase (SOD) level examination before and after 8 weeks treatment ($p=0.000$, significant level at 95%). (ST: standard diet, HF: high fat diet, HFA: high fat diet with almond, HFP: high fat diet with peanut)

Figure 5 compares all variables before and after an 8-week treatment across four dietary groups. The study indicates that a high-fat diet significantly impacts body weight, blood pressure, glucose levels, and cholesterol levels, increasing oxidative stress markers (MDA) and decreasing antioxidative enzymes (SOD). Supplementation with almonds (HFA) and peanuts (HFP) in a high-fat diet resulted in notable improvements in these health markers, bringing them closer to levels

observed in the standard diet group (ST). Specifically, nuts contributed to better glycemic control, improved lipid profiles, and enhanced antioxidative defense mechanisms. Therefore, incorporating almonds and peanuts into high-fat diets may mitigate some of the adverse health effects and improve overall metabolic health and oxidative stress balance. Further research should explore the long-term effects and the specific bioactive compounds responsible for these beneficial outcomes.

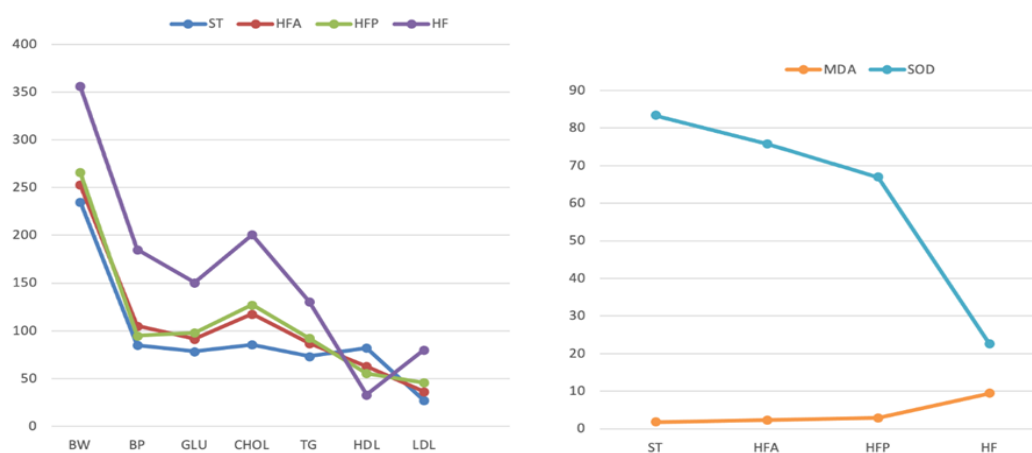


Figure 5. Comparison of all variable examination before and after 8 weeks treatment ($p=0.000$, significant level at 95%). (ST: standard diet, HF: high fat diet, HFA: high fat diet with almond, HFP: high fat diet with peanut, BW: body weight, BP: blood pressure, GLU: blood glucose level, CHOL: total cholesterol level, TG: triglyceride level, HDL: high-density lipoprotein level, LDL: low-density lipoprotein level).

Discussion

This study aimed to determine the effects of almond and peanut feeding on oxidative stress, plasma lipids, body weight, glucose, and blood pressure in Wistar strain rats to evaluate their safety for consumption. The results indicated that rats fed standard food, almonds, and peanuts regularly exhibited lower weight gain compared to those on a high-fat diet. The weight gain in the nut-supplemented groups was similar to that in the standard diet group.

Regular consumption of nuts can reduce body fat. Compared to other nuts, almonds contain higher levels of fiber, protein, monounsaturated fats, polyunsaturated fats, calcium, iron, folate, riboflavin, niacin, vitamin E, phytosterols, flavonoids, and phenolic acids (Guarneiri & Cooper, 2021). Additionally, almonds are a low-calorie food. The nut consumption, including peanuts, is associated with a lower risk of weight gain compared to other snacks such as chocolate, candy, cakes, and donuts. The high fiber content in peanuts delays gastric emptying and suppresses hunger, increasing fatty acid binding in the intestines and leading to greater faecal excretion (Dreher, 2021; Liu et al., 2019).

This study found that consumption of high-fat feed, almonds, and peanuts significantly increased body weight, glucose, cholesterol, triglycerides, malondialdehyde (MDA), superoxide dismutase (SOD), and blood pressure ($p<0.05$). The highest increases were observed in the high-fat diet group compared to the almond and peanut groups.

Rats consuming a standard diet supplemented with peanuts or almonds showed lower increases in plasma lipid and blood sugar levels compared to those on a high-fat diet. These findings are consistent with Hou et al. (2018), which reported that almonds significantly lower blood sugar levels in individuals with type 2 diabetes mellitus. Peanuts and almonds contain unsaturated fatty acids that facilitate glucose receptor movement to the cell surface, thereby

increasing insulin sensitivity. These fatty acids also stimulate GLP-1 secretion, improving β cell function and stabilizing the glycemic effect post-nut consumption (Hou et al., 2018).

A systematic review by Guasch-Ferré et al. (2023) found reductions in total cholesterol, LDL-C, and triglycerides with regular almond and peanut consumption. This study obtained similar results, showing lower cholesterol and triglyceride levels in rats consuming almonds and peanuts compared to those on a high-fat diet (Guasch-Ferré et al., 2023).

Nuts are rich in unsaturated fatty acids (MUFA and PUFA), which promote LDL clearance and reduce plasma LDL-C levels. PUFAs decrease the expression of Sterol Regulatory Element Binding Proteins (SREBPs) and cholesterol synthesis enzymes, thereby reducing the body's cholesterol pool. Legumes also increase intestinal viscosity, reducing bile acid absorption and increasing cholesterol catabolism. They enhance short-chain fatty acid synthesis by intestinal microbiota, disrupt mycelium formation in the intestinal lumen, and increase the excretion of cholesterol and bile acids through feces. This aligns with Hou et al. (2018), which showed that almonds significantly lower blood sugar levels in people with type 2 diabetes mellitus. Peanuts and almonds, containing unsaturated fatty acids, facilitate glucose receptor movement to the cell surface, increasing insulin sensitivity and GLP-1 secretion, improving β cell function, and stabilizing the glycemic effect (Hou et al., 2018).

CONCLUSION

This study indicates that almonds and peanuts can mitigate the adverse effects of a high-fat diet by reducing oxidative stress and improving lipid profiles, body weight, glucose, and blood pressure in Wistar rats. These findings support the potential health benefits of incorporating almonds and peanuts into the diet, suggesting their role in promoting metabolic health and reducing the risk of obesity-related complications. Further research should explore the specific bioactive compounds responsible for these benefits and their long-term effects on human health.

Almonds are more effective than peanuts in reducing oxidative stress and increasing antioxidant enzyme activity (SOD). Almonds also have a better effect on lowering total cholesterol, LDL and triglyceride levels than peanuts. However, both still provide benefits in improving lipid profiles and reducing the risk of cardiovascular disease.

The results of this study suggest that almonds and peanuts can be used as key ingredients in supplements or functional foods to support metabolic health. The unsaturated fatty acids, antioxidants, and fiber in nuts can be developed into products that help control blood sugar levels, lower cholesterol, and reduce oxidative stress. Further research is needed to optimize the formulation and determine the most effective dose for humans.

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