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Correlation of Body Weight with Plasma Atherogenic Index in Obese Rats Given Black Garlic

Prima Adelin[1]*, Relly Angelica Putriza[2], Haves Ashan[3], Dian Puspita[4], Rifkind[5], Letvimona[6]
Universitas Baiturrahmah [1,2,3,4,5,6]
e-mail: *primaadelin@fk.unbrah.ac.id

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ABSTRACT

Obesity triggers changes in blood lipid profiles and increases the risk of atherosclerosis, one of which is measured by the plasma atherogenic index (IAP). Black garlic contains active compounds such as allicin and S-allylcysteine, which are known to have hypolipidemic effects. This study aims to determine the relationship between changes in body weight and IAP values in obese rat models given black garlic extract. This study was a pre-post test experiment with a control, using 28 male Sprague Dawley rats divided into 4 groups: negative control (normal diet), positive control (high-fat and fructose diet), treatment dose 1 (black garlic 1.6 ml/day), and treatment dose 2 (black garlic 0.8 ml/day). Measurements of body weight and triglyceride and HDL levels were carried out before and after the intervention. The results showed that administration of black garlic caused significant changes in body weight and IAP values ($p<0.05$), but the correlation between changes in body weight and IAP values was not significant ($p>0.05$). In conclusion, there was no significant relationship between changes in body weight and IAP values in obese mice given black garlic.

Keywords: *black garlic; plasma atherogenic index; obesity*

INTRODUCTION

Obesity is a global health problem whose prevalence is increasing year by year. The WHO reports that more than 650 million adults are obese, and this condition is a major risk factor for metabolic and cardiovascular diseases. One important parameter in assessing the risk of atherosclerosis is the Plasma Atherogenic Index (API), calculated from the log10 ratio of triglycerides to HDL. The Plasma Atherogenic Index has been shown to be associated with the formation of atherogenic small, dense LDL and is used as a predictive biomarker for coronary heart disease (Fawwad et al., 2023; Huang et al., 2023; Jebari-Benslaiman et al., 2022; Sadeghi et al., 2021).

*Black garlic*Black garlic (Allium sativum L.) has been studied for its antioxidant and hypolipidemic effects, particularly in lowering triglyceride levels and increasing HDL. The role of black garlic in changing IAP values specifically in animal models of obesity remains largely unknown. Some studies have shown that weight loss does not always align with IAP improvements, suggesting that other mechanisms may be at play. This provides an important basis for evaluating the effects of natural therapies such as black garlic (Morawati et al., 2024; Recinella et al., 2020).

A research gap is evident in the lack of studies evaluating the direct correlation between weight change and IAP levels in experimental models, especially with natural interventions like black garlic. Existing studies generally only evaluate a single lipid parameter, without comprehensively linking it to atherosclerosis risk through IAP (Adelin et al., 2022; Kaniawati, 2020; Sadeghi et al., 2021; Zhang et al., 2019). Clinical research by Nurisma et al. showed a significant correlation between IAP values and the degree of stenosis in patients with stable coronary heart disease, strengthening IAP values as an indicator that can be widely used, not only in clinical populations but also in experimental studies (Nurisma et al., 2025; Sa'Adah et al., 2017)

This study aimed to examine the relationship between changes in body weight and IAP values in obese mice treated with black garlic. The novelty of this study lies in the simultaneous observation of two interrelated parameters body weight and IAP in a single animal model, to evaluate black garlic's potential in reducing atherogenic risk due to obesity.

METHODOLOGY

This experimental study, using a pre-post test with a control group design, aimed to evaluate the effect of black garlic extract on changes in body weight and the Plasma Atherogenic Index (PIA) in obese rat models. This design allowed researchers to compare parameters before and after the intervention, as well as between the treatment and control groups.

The population in this study were male white rats of the Sprague Dawley strain (Rattus norvegicus) aged 2–3 months with an initial body weight ranging from 150–200 grams. The number of samples was 28 rats, which were randomly divided into four groups (n=7 per group), namely: (1) a negative control group fed with standard AIN-93 feed, (2) a positive control group fed with a high-fat and fructose diet (DHLF), (3) a dose 1 treatment group (D1) fed with DHLF + black garlic extract 0.8 ml/day, and (4) a dose 2 treatment group (D2) fed DHLF + black garlic extract 1.6 ml/day. Obesity induction was carried out for 12 weeks using a high-fat and fructose diet. Black garlic intervention was given for 14 days after obesity induction.

Data were collected through weekly body weight measurements of the mice during the induction and intervention periods. Blood samples were taken via the retro-orbital vein on days 84 (before intervention) and 98 (after intervention) to determine triglyceride and HDL levels using

spectrophotometry. IAP values were calculated using the formula log10(triglycerides/HDL).

The data obtained were analyzed using SPSS version 25.0 software. Analysis was performed using a paired t-test to assess changes within groups, ANOVA for inter-group comparisons, and Pearson correlation to assess the relationship between weight changes and IAP values. Results were considered significant if the p-value was <0.05.

RESULTS AND DISCUSSION

This study evaluated the effect of black garlic administration on body weight and the Plasma Atherogenic Index (PIA) in obese mice. Observations were conducted on four groups, each consisting of seven mice. Data on the average changes in body weight and PIA values are shown in Table 1.

Table 1. Average Body Weight and IAP Values of Mice Before and After Intervention

Sample Group	Heavy Body (Pre-test)				
	Average (grams)	Elementary School	MIN	MAX	P-value
K-	249.29	12.46	236	275	0,000
K+	299.14	17.66	282	331	0,000
P1	273.57	21.27	233	299	0,000
P2	268.29	18.31	245	299	0,000

Source: 2025 Data Processing Results

The results of measurements of the body weight of mice in the 12th week after the diet administration showed significant differences between groups. The highest average body weight was found in the positive control group (K+), namely 299.14 ± 17.66 grams, while the negative control group (K-) showed the lowest average body weight, namely 249.29 ± 12.46 grams. This difference indicates that obesity induction using a high-fat and fructose diet for 12 weeks succeeded in increasing body weight significantly (p = 0.000).

The treatment groups (P1 and P2) also showed increased body weight compared to the K- group, with an average of 273.57 ± 21.27 grams and 268.29 ± 18.31 grams, respectively. These values were between the K- and K+ groups, indicating that mice in the treatment groups experienced metabolic changes resembling obesity, although not as high as the positive control group. This indicates that all non-K- groups had experienced an obese metabolic state before the start of the black garlic intervention.

This successful obesity induction provides an important basis for evaluating the effects of black garlic intervention on subsequent metabolic parameters. These findings are supported by an experimental study by Chang et al. (2017), which showed that black garlic supplementation with a high-fat diet for 6 weeks significantly reduced final body weight, visceral fat

accumulation, and serum triglyceride levels in male Wistar rats. Furthermore, the study also reported a significant increase in the activity of liver antioxidant enzymes such as GPx, GRd, and GSH, as well as a decrease in GSSG.

This indicates that the antiobesity effect of black garlic works not only through lipid profile regulation but also through protection against oxidative stress, which triggers chronic inflammation in obesity. Interestingly, the reduction in body weight and visceral fat was not accompanied by a decrease in food intake, indicating that black garlic exerts a direct metabolic effect without affecting appetite or energy consumption. This supports the results of the current study, which showed a decrease in IAP values as an indicator of atherosclerosis risk, although the direct correlation with weight change was not significant. This suggests that black garlic acts multifactorially not only as an antiobesity agent, but also as an antiatherogenic agent and antioxidant, as demonstrated by Chang et al. and the results of this study (Chang et al., 2017).

Changes in IAP values showed a different pattern. The positive control group experienced an increase in IAP values of 0.11, indicating an increased atherogenic risk due to a high-fat diet. Meanwhile, both treatment groups showed a decrease in IAP values, with the highest decrease in the 1.6 ml/day dose group (-0.07). This confirms the hypothesis that black garlic has a hypolipidemic effect by reducing triglyceride levels and increasing HDL.

Figure 1. Average Change in Body Weight of Mice per Group

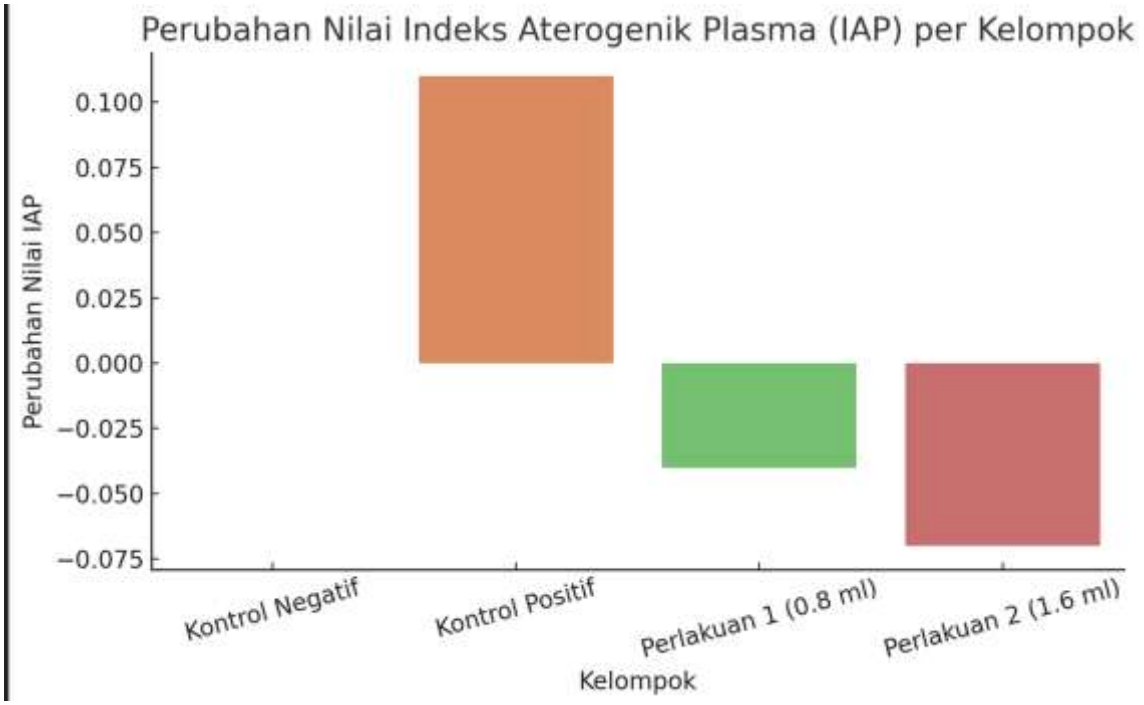

Figure 2. Change in Average IAP Value per Group

These research findings are supported by a clinical study by Villaño et al. (2023), which showed that consuming black garlic for 12 weeks can increase HDL levels and reduce the atherogenic index in both hypercholesterolemic and healthy subjects (Villaño et al., 2023). The decrease in endothelial adhesion molecules such as ICAM-1, VCAM-1, and MCP-1 in that study also indicates improved endothelial function and a reduced risk of vascular inflammation. The decrease in the atherogenic index in the healthy group indicates a protective effect of black garlic even in undisturbed metabolic conditions. These findings align with the results of this study, where black garlic administration contributed to a decrease in IAP, although not entirely proportional to weight loss.

A review study by Ahmed et al. (2023) also emphasized that the organosulfur compounds (OSCs) in black garlic, such as S-allylcysteine (SAC), play a crucial role in antioxidant, anti-inflammatory, and lipid-lowering mechanisms. SAC has been shown to increase the expression of antioxidant enzymes such as SOD and GPx and inhibit inflammatory pathways that contribute to endothelial dysfunction and atherogenesis. Black garlic has also been shown to have higher OSC bioavailability than fresh garlic, further enhancing its biological effects on the cardiovascular system (Ahmed & Wang, 2021).

Furthermore, Rosa et al. (2020) reported in an animal study that black garlic extract reduced body weight, total cholesterol, triglycerides, and LDL, while increasing HDL in mice induced with hypercholesterolemia. This study also noted increased antioxidant enzyme activity and improved liver tissue structure, strengthening the systemic protective mechanisms of black garlic.

These findings support Ibu's research that black garlic can reduce the risk of atherosclerosis in a multifactorial manner—not only through its effects on body weight, but also through lipid regulation and oxidative stress (Valls et al., 2022).

CONCLUSION

This study shows that administering black garlic extract to obese mice affected changes in body weight and the Plasma Atherogenic Index (IAP). Although weight loss and IAP values were observed separately in the treatment group, correlation tests showed no significant relationship between weight change and IAP values. This indicates that improvements in lipid profiles, particularly IAP, can occur independently of weight loss.

Black garlic has potential as a complementary therapeutic agent in reducing atherogenic risk in obesity, but its effectiveness on body weight and IAP may be influenced by factors such as dose, duration, and individual variability in biological response. Further research is needed to explore the molecular mechanisms involved and evaluate the long-term effects of black garlic intervention.

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