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Efficacy of edamame vs. almond consumption on total cholesterol in reproductive-age women

Perbandingan efektivitas konsumsi kacang edamame dan kacang almond dalam menurunkan kadar kolesterol total wanita usia subur

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Abstract

Hypercholesterolemia in adults over 18 years of age poses a significant health risk. Reproductive-age women are susceptible to this condition owing to unhealthy dietary habits, notably consumption of fast food. This study aimed to investigate the potential of edamame and almonds to lower blood cholesterol levels. This study employed a pre-test post-test group design following a 6-week intervention. Twenty-eight participants were recruited through consecutive sampling conducted in Purwokerto between March and August of 2022. Statistical analyses were performed using independent and paired t-tests. Results indicated no significant difference in the effectiveness of edamame and almonds in reducing total cholesterol levels among reproductive-age women (p= 0.534). After consumption of 48.8 g/d edamame for 6 weeks, a substantial decrease in total cholesterol levels was observed (p= 0.004), with a mean reduction of 17.79 ± 19.11 mg/dL. Conversely, the intervention with 42.5 g/d of almonds for 6 weeks did not significantly change total cholesterol levels (p= 0.193), yielding a mean reduction of 11.57 ± 31.51 mg/dL. In conclusion, the consumption of edamame for six weeks is effective in lowering total cholesterol levels among women of reproductive age.

Keywords: Almond, edamame, cholesterol-lowering foods, hypercholesterolemia,

Abstrak

Hiperkolesterolemia pada orang dewasa usia >18 tahun dapat menimbulkan masalah kesehatan. Wanita usia subur memiliki risiko hiperkolesterolemia karena gaya hidup tidak sehat seperti kebiasaan konsumsi *fast food*. Salah satu faktor yang dapat menurunkan kadar kolesterol darah yaitu memilih makanan yang mengandung isoflavon dan fitosterol, seperti dalam edamame dan kacang almond. Penelitian ini bertujuan untuk mengetahui perbedaan efektivitas edamame dengan almond dalam menurunkan kadar kolesterol total wanita usia subur. Penelitian ini merupakan penelitian *true experimental* dengan *pre-test post-test* dengan waktu intervensi 6 minggu. 28 responden terpilih dengan metode *consecutive sampling* dan dilaksanakan di Purwokerto pada Maret – Agustus 2022. Analisis bivariat yang digunakan dalam penelitian ini yaitu uji *Independent T-test* dan *Paired T-test*. Hasil, tidak terdapat perbedaan efektivitas edamame dengan almond dalam menurunkan kadar kolesterol total (p= 0,534). Terdapat perubahan kadar kolesterol total yang bermakna setelah konsumsi edamame 48,8 g/hari selama 6 minggu (p=0,004) sebesar -17,79 ± 19,11 mg/dl. Tidak terdapat perubahan kadar kolesterol total yang bermakna setelah konsumsi almond 42,5 g/hari selama 6 minggu (p=0,193) sebesar -11,57 ± 31,51 mg/dl. Kesimpulan, konsumsi kacang edamame dan almond selama 6

minggu efektif menurunkan kadar kolesterol total wanita usia subur, dengan edamame memberikan penurunan yang lebih signifikan.
Kata Kunci: Almond, edamame, hiperkolesterolemia, makanan penurun kolesterol

Introduction

Hypercholesterolemia, defined as a condition characterised by elevated cholesterol levels exceeding the established normal threshold (>190 mg/dl) in adults aged ≥ 18 years, represents a significant health concern (Ministry of Health, Republic of Indonesia, 2017; World Health Organization, 2021). Elevated blood cholesterol levels can detrimentally affect circulatory dynamics and substantially increase the risk of cardiovascular ailments, including stroke and fatal heart disease(World Health Organization, 2020). Globally, 2.6 million deaths, constituting 4,5% of total mortalities, can be attributed to elevated total cholesterol levels, as reported by the WHO in 2021 (World Health Organization, 2021).

Hypercholesterolemia has a substantial prevalence and, thus, warrants comprehensive global attention (Puspaningdyah, 2020). Empirical data derived from the Health Center (HC) and Integrated Coaching Post (ICP) dedicated to non-communicable diseases revealed a 52,3% incidence of high cholesterol in Indonesia, with a sex-specific breakdown of 48% in men and 54,3% in women (Ministry of Health Republic of Indonesia, 2017). The Basic Health Research (Riskesdas) 2018 in Central Java identified 3,273 adults who underwent assessments at ICP or HC, with 48.1% exhibiting elevated blood cholesterol levels (Ministry of Health Republic of Indonesia, 2018).

The susceptibility of women to hypercholesterolemia increases with age, owing to a decline in endogenous estrogen production (Wahyuningsih & Wirawanni, 2014; Mulyani et al., 2018). Additionally, advancing age correlates with elevated LDL levels in the bloodstream, a phenomenon attributed to diminished low-density lipoprotein receptor functionality, thereby leading to increased cholesterol levels (Saputri & Novitasari, 2021; Al Rahmad, 2021). Notably, even women of reproductive age (20-45 years) face a considerable risk of hypercholesterolemia, which is exacerbated by unhealthy lifestyle practices such as the consumption of fast food, as previously reported (Firdaus & Adhitama, 2020).

Early preventive interventions are imperative to mitigate the incidence of hypercholesterolemia in younger women. Various factors can influence the maintenance or reduction of cholesterol levels. Engaging in regular physical activity, limiting dietary fat intake, and selecting foods rich in isoflavones can aid in cholesterol management. Isoflavones, specifically genistein and daidzein, are abundant in numerous nuts and exhibit cholesterol-lowering properties (Sulistyaningsih & Mulyati, 2015).

Edamame (*Glycine max (L.) Merr.*), originating from Japan, can be cultivated effectively in tropical and subtropical regions, including Indonesia. Edamame is a potential functional food source owing to its bioactive components, notably the omega-3 fatty acid eicosapentaenoic acid (EPA) and omega-6 fatty acid arachidonic acid (ARA) (Aliyah & Setiawati, 2018). For every 100 g of edamame, 361 mg of omega-3 fatty acids and 1,794 mg of omega-6 fatty acids were found (Sudiarti, 2018). Additionally, edamame contains 49 mg/80 g of isoflavones, which confer protective effects against non-communicable diseases such as hyperlipidemia, hypertension, stroke, and heart disease (Aliyah & Setiawati, 2018; Ningsih et al., 2018). Research indicates that consuming Edamame tempeh flour for 5,4g/200 g weight in dyslipidemic rats for 28 days can yield a 40.92 mg/dL reduction in LDL cholesterol levels (Nurkistin, 2022).

Almonds have also garnered extensive attention because of their cholesterol-lowering properties. Almonds possess a rich profile of vegetable protein, dietary fiber, unsaturated fatty acids, micronutrients, and l-arginine, a precursor with a cholesterol-reducing role (Berryman et al., 2015). Phytosterols present in almonds, at approximately 187 mg/100 g, play a pivotal role in cholesterol management by reducing cholesterol absorption and partially inhibiting cholesterol biosynthesis (Safitri, 2018). Scientific investigations have revealed that consuming 42.5 g/day of almonds for 6 weeks can reduce LDL cholesterol levels by 5.3 mg/dL (Berryman et al., 2015).

Considering these findings, edamame and almonds have emerged as promising dietary components for individuals with hypercholesterolemia. Thus, this study aimed to assess and compare the efficacy of edamame and almond consumption in reducing blood cholesterol levels in women of reproductive age.

We found it crucial to compare the efficacy of edamame and almond on blood cholesterol levels, as both currently emerge as popular foods among the public and are believed to have positive effects on health. Almonds and edamame are easily accessible in both traditional markets and e-commerce. However, there is currently no scientific information guiding the public on the recommended consumption of edamame and almonds and the specific health effects associated with their consumption.

Methods

This study was conducted in the Purwokerto area over six months, from March 2022 to August 2022, starting from conceptualized research design and ethical clearance application until the data analysis process was completed. This study incorporated pre- and post-test measurements using a true experimental research design. It encompassed two distinct treatment groups: treatment group one, which received edamame, and treatment group two, which received almond nuts. Notably, a control group was not used in this study, as the primary objective was to evaluate the efficacy of these two interventions in ameliorating blood cholesterol levels.

The inclusion criteria for selecting participants in this study were women of reproductive age, specifically within the 20-40 years age bracket, who exhibited total cholesterol levels exceeding the threshold indicative of borderline high risk (≥190 mg/dL) (Ministry of Health Republic of Indonesia, 2017; CDC, 2019) during the screening process based on the results of checking blood samples carried out by health workers.

Conversely, the exclusion criteria in this study were women with pre-existing consumption of cholesterol-lowering medication and those diagnosed with medical conditions such as diabetes mellitus or atherosclerosis.

A consecutive sampling approach was employed to achieve participant inclusion. All potential respondents who were matched with the inclusion criteria and agreed to participate in this study were immediately included as participants. This process was repeated consecutively until the participants reached a minimum sample size of 28. We obtained written informed consent from all participants, and the potential risks and benefits were declared beforehand. All 28 participants were randomly separated into two groups: edamame and almond, each consisting of 14. All participants actively participated in the research until their conclusion, which resulted in no reduction in the number of samples in this study.

The study will span six weeks, focusing on the impact of dietary intake on blood cholesterol levels during this period. The prescribed daily dosage for study participants will be 48.8 g of edamame and 42.5 g of almonds, as informed by prior research (Berryman et al., 2015; Jenkins et al., 2010). Steamed edamame and roasted almonds were used as the selected forms of consumption.

Potential confounding factors were controlled by strict adherence to the inclusion criteria for the participants selected for this study. Pertinent alterations in total cholesterol levels, observed before and after the administration of edamame and almond, were evaluated using a paired t-test, given the normal distribution of the data. Moreover, the difference between total cholesterol levels after edamame and almond consumption was assessed using the independent t-test for normally distributed data, whereas the Mann-Whitney U test was applied for data that did not conform to normal distribution assumptions.

In adherence to ethical standards, the research protocols were scrutinized, and formal approval was received from the Health Research Ethics Commission (reference number 032/KEPK/PE/V/2022). This ethical approval was officially granted on May 25, 2022, ensuring compliance with the established research ethics and guidelines. All the data supporting this study are included in this article.

Result and Discussion

Table 1 illustrates the absence of statistically significant differences in the BMI characteristics ($p=0.301$) and total cholesterol levels ($p=0.293$) between the almond and edamame intervention groups. This observation underscores the homogeneity of the participants in terms of their

initial nutritional status and total cholesterol levels, reaffirming that all participants commenced the study with elevated total cholesterol levels exceeding the norm. Although a significant difference in age characteristics was noted among the participants (p=0.039), it is noteworthy that all participants adhered to the inclusion criteria, which specifically targeted women of reproductive age between 20-45 years. Consequently, this age variance is unlikely to exert any discernible influence on the ultimate research outcomes. Notably, most participants fell within the 20-24-year age category in both the edamame and almond groups.

Table 1. Participant's characteristics

Variable	Edamame Group (n=14)			Almond Group (n=14)			p-value
	n	%	Mean ± SD	n	%	Mean ± SD	
Age Average (years old)			23.50 ± 4.93			29.57 ± 8.37	0.039[b]
Age Group (years old)							
20 - 24	12	85.7		7	50		
25 - 29	1	7.1		0	0		
30 – 34	0	0		2	14.3		
35 – 39	1	7.1		3	21.4		
40 – 44	0	0		2	14.3		
Occupation							
Students	12	85.7		7	50		
Housewife	2	14.3		3	21.4		
Civil Servant	0	0		3	21.4		
Owned Enterprises	0	0		1	7.14		
Body Mass Index (kg/m^2)			25.71 ± 6.58			23.72 ± 3.91	0.301[b]
Underweight	1	7.1		0	0		
Normal	4	28.6		9	32.1		
Overweight	1	7.1		1	7.1		
Obesity Stage I	6	42.9		3	21.4		
Obesity Stage II	2	14.3		1	7.1		
Total Cholesterol (mg/dL)			217.36 ± 19.80			230.86 ± 22.19	0.656

Notes: a= Independent t-test, b =Mann-Whitney test

The prevalence of high cholesterol levels in this age group underscores the escalating significance of early detection and intervention for hypercholesterolemia. Women of reproductive age, including those as young as 20 years, are predisposed to hypercholesterolemia. Prior investigations suggest that women within this age bracket often tend to neglect their health and adopt unhealthy dietary habits, including fast food consumption (Firdaus & Adhitama, 2020; Rahmad, 2019). This age cohort, commonly referred to as young adults, is particularly susceptible to experimentation with diverse foods guided by exposure and peer influences and frequently opts for high-fat and cholesterol-rich dietary choices. Furthermore, age-related factors contribute to the decreased elasticity of arteries, rendering them narrower and stiffer. This diminished elasticity results in a more confined region being subjected to systolic pressure, culminating in an elevated blood pressure. Notably, increased cholesterol levels increase the risk for hypertension (Maryati, 2017).

As shown in Table 2, a significant decrease in total cholesterol levels was evident following the 6-week intervention (p= 0.004). Specifically, the mean total cholesterol level prior to the intervention stood at 217.36 ± 19.80 mg/dl, whereas after the intervention, it was recorded as 199.57 ± 26.45 mg/dl. This signifies a notable reduction in total cholesterol (Δ TC) levels post-intervention, amounting to -17.79 ± 19.11 mg/dl.

The reduction in total cholesterol levels documented in this study aligns with the findings reported by Jenkins et al. (2010), wherein a significant decrease of 7 mg/dl in LDL cholesterol levels was observed following consuming 24.4 g/day of edamame over 3 weeks. This cholesterol-lowering effect was attributed to the isoflavone content of edamame. Isoflavones are secondary metabolites commonly found in legumes such as edamame.

Edamame, a variant of soybean (*Glycine max (L) Merr*), belongs to the genus Glycine and family Leguminosae (Prasetyo, 2017). Isoflavones can be enzymatically converted to free isoflavones, referred to as aglycones, which include genistein, glistein, and daidzein. Notably, edamame has a higher isoflavone content than conventional soybeans, with processed edamame containing an average of 49 mg of total isoflavones per 80 g, as opposed to 24 mg in standard soy (Ningsih et al., 2018).

Isoflavones are sterols originating from plants or phytosterols (Riyanto & Muwarni, 2016), which are antioxidants that can inhibit cholesterol absorption in the liver and from food (Munabari & Ikawati, 2018). Genistein is an isoflavone that inhibits cholesterol biosynthesis by activating adenosine monophosphate-activated protein kinase (AMPK). Activation of this enzyme can inhibit the reduction of HMG-CoA to mevalonate, thereby reducing cholesterol biosynthesis (Fitranti & Marthandaru, 2016).

Table 2. Blood total cholesterol level after edamame intervention

Variable	Total Cholesterol (TC) Level		p-value	Increments (mg/dl)
	Before (mg/dl)	After (mg/dl)		
Edamame Group (n=14) Mean ± SD	217.36 ± 19.80	199.57 ± 26.45	0.004*	17.79 ± 19.11
Almond Group (n=14) Mean ± SD	230.86 ± 22.19	219.29 ± 26.17	0.193	11.57 ± 31.51

Notes: a= Paired T-test, *= Significance on p<0.05

Table 2 presents a p-value of 0.193, suggesting the absence of a statistically significant change in total cholesterol levels after the 6-week almond intervention. The mean total cholesterol level before the intervention was 229.92 ± 22.80 mg/dl; after the intervention, it was 224.46 ± 18,33 mg/dl. Consequently, the decrease in total cholesterol levels (ΔTC) post-almond intervention equated to 11.57 ± 31.51 mg/dl.

This research outcome diverges from the study conducted by Berryman et al. (2015), wherein participants aged 30-65 years were administered 42.5 g/day almonds over 6 weeks, resulting in a significant change (p=0.04) in total cholesterol levels, with a reduction of 5.1 mg/dl. The roasting process applied to almonds may partially account for this discrepancy, as it has the potential to reduce the levels of flavonoids and phenolic compounds, given their thermolabile nature. However, according to former study led by (Aboudou et al., 2020). Roasted almonds were chosen for this study because of their widespread availability in the market and their accessibility to the public.

Although statistically insignificant, it is noteworthy that almonds still exhibited potential to reduce total cholesterol levels, as corroborated by the findings of this study. Almonds belong to the category of nuts that are rich in insoluble dietary fibre (Konaté et al., 2010). Dietary fiber functions as an antioxidant and can lower LDL cholesterol and elevate HDL cholesterol levels (Konaté et al., 2010). Almonds contain a diverse array of phenolic compounds, vitamin E, and polyphenols that collectively act as antioxidants and shield membrane fatty acids from lipid peroxidation (Nareswara & Anjani, 2016).

Flavonoids present in almond skin have demonstrated antioxidant activity in vitro and synergise with vitamin E to inhibit LDL oxidation in animal models, such as hamsters (Kalita et al., 2018). Flavonoids, classified as antioxidant compounds, are pivotal in neutralizing free radicals. They engage with reactive radical compounds, stabilizing the reactive oxygen species (ROS). This can be attributed to the high reactivity of the hydroxyl groups in the flavonoids, which makes the free radicals inert. The higher the flavonoid content in food, the greater is the potential to bolster the activity of endogenous antioxidants (Lubis & Anjani, 2016).

Based on the independent t-test outcomes delineated in Table 3, no significant difference in total cholesterol levels (ΔTC) (p= 0.534) was discerned between the edamame intervention group (17.79 ± 19.11 mg/dl) and the almond intervention group (11.57 ± 31.51 mg/dl). This led to the conclusion that both interventions lowered total cholesterol levels, but only edamame had a significant effect.

Table 3. The differences of Total Cholesterol (TC) reduction between edamame and almond group

Variable	Total Cholesterol (TC) After (mg/dl)	ΔTC	p-value[a]
Edamame Group (n=14)			
Mean ± SD	199.57 ± 26.45	17.79 ± 19.11	0.534
Almond Group (n=14)			
Mean ± SD	224.46 ± 18.32	11.57 ± 31.51	

Notes: a = independent t-test

Both edamame and almond contain phytosterols. Edamames are rich in isoflavones, which are a type of plant sterol, and serve as potent antioxidants capable of restraining cholesterol absorption, whether from hepatic synthesis or dietary sources (Munabari & Ikawati, 2018). Processed edamame contains an average of 49 mg of total isoflavones per 80 g, whereas standard soy contains 24 mg isoflavones (Ningsih et al., 2018). In contrast, almonds contain phytosterols that are recognized for their efficacy in reducing blood cholesterol levels, with an estimated content of approximately 187 mg per 100 g (Safitri, 2018).

Phytosterols belong to the steroid compound class and exhibit a triterpene structure similar to that of cholesterol in animals, differing only in skeletal side chains (Francavilla et al., 2012). Owing to their structural similarities, phytosterols and cholesterol engage in a competitive absorption process within the digestive system when concurrently ingested, leading to reduced cholesterol levels within the body (Jati et al., 2019). Phytosterols also impede the reabsorption of cholesterol-rich bile acids by modulating the activity of 7α-dehydroxylase and acetyl-CoA, thereby increasing the excretion of bile acids through fecal elimination. This reduces the bile acid pool and increases the formation of new bile acids from cholesterol in the bloodstream (Jufri et al., 2015).

Our study was the first in Indonesia to compare the efficacy of edamame and almonds on blood cholesterol levels. After 6-weeks of intervention, no side effects were reported by our participants after their involvement in this study. Thus, we concluded that consumption of edamame and almond for 6-week implies no negative effect on the target population, unless one already has an allergy to nuts.

Conclusion

The study found that edamame consumption led to a significant reduction in total cholesterol levels after a 6-week intervention, whereas almond consumption did not. The comparison showed no significant difference in cholesterol levels between the two groups; however, edamame consumption had a more significant cholesterol-lowering effect.

It is advisable for women of reproductive age, particularly those afflicted with hypercholesterolemia, to consider incorporating edamame into their diet. The outcomes of this study have practical implications for daily life, wherein individuals can modify their dietary habits by consuming 48,8 g of edamame as wholesome snacks to mitigate total cholesterol levels.

We suggest that future studies should prolong the intervention period and focus more on other cardioprotective effects of edamame and almond regular consumption.

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Author contributions: ARS acted as the principal investigator, conceptualized and designed the study, and prepared and reviewed the manuscript; HPS and F led the data analysis and interpretation and reviewed the manuscript; EES and NAR conducted data collection, assisted in drafting the manuscript, and reviewed the manuscript. All the authors agree with the final draft of the manuscript.

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