

# The Effect of High Fiber Consumption Patterns on Lowering Cholesterol Levels Low Density Lipoprotein: Literature Review

Heri Saputro\*, Lutfi Ema Rifani

Institut Ilmu Kesehatan STRADA Indonesia, East Java, Indonesia

\*Corresponden Author: Heri Saputro ([nsheri@iik-strada.ac.id](mailto:nsheri@iik-strada.ac.id))

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## ABSTRACT

**Background:** Hypercholesterolemia can cause blockages in blood vessels and heart. Not infrequently people with hypercholesterolemia will experience myocardial infarction in the heart which leads to death. Changes in lifestyle are characterized by consuming less fiber-containing foods which have an impact on increasing LDL cholesterol levels in the blood. This study aimed to determine the effect of the application of high fiber consumption patterns on the reduction of cholesterol levels. **Method:** Literature review from the Google Scholar database, Pubmed published from 2010 to 2020, and manually select articles that are relevant to the research statement and use the keywords high fiber consumption patterns and hypercholesterolemia. **Results:** From the results of the literature review conducted, it was found that there were 10 related articles that met the criteria. **Results:** The results of the search are obtained by consuming a high-fiber diet (avocado, guava and dragon fruit, carrots and tomatoes, etc.) which produce nutrients and antioxidants such as anthocyanins, flavonoids, lycopene, PUFA, MUFA, niacin, fiber, vitamin C and phytosterols which can help lower LDL cholesterol levels and increase HDL. **Conclusion:** There is a relationship between the pattern of consumption of high-fiber foods to decrease cholesterol levels. With a high-fiber consumption pattern, it can bind bile acids and then excreted together with feces, this acid can reduce LDL cholesterol levels.

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## I. Introduction

Currently, degenerative diseases are a global health problem, including in Indonesia, one of which is heart disease due to blockage of blood flow caused by high levels of cholesterol in the blood. Hypercholesterolemia is where cholesterol levels in the blood exceed the normal rate, which is more than 240 mg/dL. Hypercholesterolemia is one of the degenerative diseases that is the biggest death in the world and even increases every year. The risk factor that is the main cause of hypercholesterolemia is the lack of control of eating patterns in everyday life. Hypercholesterolemia can cause blockages in blood vessels and heart. Not infrequently people with hypercholesterolemia will experience myocardial infarction in the heart which leads to death (Annies, 2015).

Hypercholesterolemia can occur because of the high fat fraction, namely an increase in total and LDL cholesterol levels, while HDL tends to decrease. If left continuously, cholesterol will stick to the walls of blood vessels and cause flakes in blood vessels that can cause coronary heart disease. Hypercholesterolemia causes more than 50% of stroke and coronary heart events (Churilla, 2013).

From WHO (World Health Organization) data, in 2017 cardiovascular disease was the biggest cause of death in the world as many as 17.7 million, in 2015 with a percentage of 31%. The prevalence of hypercholesterolemia in the adult population is 39.0%, and it is estimated that by 2030 it will increase. According to the 2018 Riskesdas, the prevalence of CHD in Indonesia caused by hypercholesterolemia is 1.5% covering all ages. Meanwhile, according to Riskesdas in 2013 in the age group of 25-34 years by 9.3% and increasing according to age to 15.5% at the age of 55 years and over. In the population aged > 15 years, there was an abnormal cholesterol level of 35.9%. Meanwhile, according to the 2014 Ministry of Health, the prevalence of hypercholesterolemia in Indonesia in the adult population is 35.9%, in urban areas by 39.5% and in rural areas by 32.1%. The latest survey in Indonesia reached 70% of people with heart disease due to hypercholesterolemia (Mumpun, 2011).

The cause of increased cholesterol levels due to lifestyle changes among modern society such as less consumption of high-fiber foods, lack of activity, environmental factors, and stress factors. Several factors that affect cholesterol levels are low fiber diet, high fat diet, smoking habits, and lack of physical activity. By consuming fiber, it has the potential to reduce cholesterol levels by binding to fat in the small intestine, binding bile acids, and increasing faecal excretion (Fairudz & Nisa, 2015). Meanwhile, by consuming foods that contain at least 28 grams of fiber will reduce cholesterol levels in the blood by 15-19% (Yuliatini E et al, 2015).

Fiber intake is one of the vegetable food ingredients that can be consumed and can be absorbed by the small intestine and undergoes fermentation throughout the small intestine (Howlett et al, 2010). Diets high in dietary fiber >25 g/day were associated with lower cholesterol levels. The American Heart Association (AHA) recommends increasing fiber intake by 25 to 30 g/day to lower lipids, especially in reducing LDL levels in the blood.

Many studies have investigated the effect of fiber consumption on reducing LDL cholesterol levels. One of them is the Randomized Controlled Trial (RCT) in China. This study was conducted on hypercholesterolemic patients who were given oat cereal as a source of fiber intake. The study proved that giving 100 grams of oats for 6 weeks could reduce LDL cholesterol levels by 8.4% compared to the control group by 3.5% (Zhang J, 2012). Meanwhile, according to research by Nur Ifani Shafira (2020) fiber consumption has a significant relationship with hypercholesterolemia (p-value <0.05). The results of the bivariate analysis showed that the relationship between low fiber consumption and the incidence of hypercholesterolemia had a PR value = 2.42 and a 95% CI (95% confidence interval) = 1.33–4.43 (p-value = 0.002). Based on the results of the analysis, it can be concluded that people with low fiber consumption (<25 grams/day) have a 2.42 times greater risk of developing hypercholesterolemia compared to people with moderate fiber consumption (≥25 grams/day).

The level of fiber adequacy affects the decrease in total cholesterol levels. This is in line with the theory of fiber lowering cholesterol by preventing cholesterol synthesis from occurring at the stage of inhibiting the activity of the HMG-co A reductase enzyme. Another mechanism for lowering cholesterol in the body is an increase in bile secretion and an increase in cholesterol excretion from food intake. Waloya's research (2013) showed that the level of fiber adequacy had an effect on reducing total blood cholesterol levels (p = 0.001). According to YunitaDianaSari's (2014) research results, it was found that the results showed all (100.0%) respondents consumed dietary fiber below the recommended 25 grams/day. Dietary fiber intake was not significantly related to LDL cholesterol levels. The variables of age, fat intake and vegetable protein intake were significantly related to LDL cholesterol levels.

While in fiber intake such as vegetables, fruits, and seeds contain substances that can reduce total cholesterol levels such as anthocyanins, lycopene, niacin, vitamin C, flavonoids, PUFA, MUFA and water soluble fiber. The mechanism of anthocyanins in reducing total cholesterol levels is by activating AMP-activated protein kinase (AMPK) which functions to inhibit the HMG-CoA reductase enzyme so that it can inhibit cholesterol synthesis and reduce its levels in the blood. In addition, anthocyanins increase the excretion of cholesterol through feces. Wallace T's research (2016) showed that 8.01 mg of anthocyanins can reduce LDL cholesterol levels by 56 mg/dl (p<0.05). while flavonoids work as inhibitors of the HMG-CoA reductase enzyme so that cholesterol synthesis decreases. Flavonoids in

dragon fruit of 7.2 mg support 30% of the total 23 mg needed to lower cholesterol according to Simanjuntak's research (2012). Niacin functions to reduce VLDL production, so that IDL-cholesterol and LDL-cholesterol levels will decrease so that it has an impact on decreasing total cholesterol levels and increasing HDL levels in the blood. PUFA and MUFA function to increase the secretion of the enzyme cholesterol 7 $\alpha$  hydroxylase so that there is an increase in the conversion of cholesterol to bile acids. Phytosterols function to inhibit the absorption of cholesterol in the intestines. Triliana's research (2012) showed that giving 50 mg/day of phytosterols to rats for 6 weeks could reduce LDL cholesterol levels by 44.3%. The American Diet Association (ADA) recommends a daily fiber intake of 25-30 g/day for adults.

Therefore, the effort that can be done to prevent an increase in LDL cholesterol levels is to control the consumption pattern of high-fiber foods such as consuming various fruits and vegetables.

Based on the background description that has been described above, the researchers are interested in conducting research with the title "The effect of the application of high fiber consumption patterns on the reduction of cholesterol levels".

## II. METHODS

In this study, the researcher used a literature review design. The literature review is sourced from the Google Scholar and Pubmed databases published from 2010 to 2020, and manually selects articles that are relevant to the researcher's statement.

## III. RESULTS

This literature review describes 10 articles that discuss the pattern of consumption of high-fiber foods, LDL (Low Density Lipoprotein), HDL (High Density Lipoprotein) cholesterol, and Total Cholesterol in reducing cholesterol levels in the blood.

According to Yunita Diana Sari's (2014) research results, it was found that the results showed all (100.0%) respondents consumed dietary fiber below the recommended 25 grams/day. Dietary fiber intake was not significantly related to LDL cholesterol levels. The variables of age, fat intake and vegetable protein intake were significantly related to LDL cholesterol levels.

According to the results of Adinda Maharani's research (2018), the results showed that there was a significant relationship between fiber intake and blood cholesterol levels ( $P < 0.05$ ), with a P Value of 0.046. It is also known that the OR is 7.724, which means that respondents with normal fiber intake have a possible normal cholesterol level of 7.724.

According to the research results of Nur Ifani Shafira (2020) Research Results Fiber consumption has a significant relationship with hypercholesterolemia ( $p$ -value  $< 0.05$ ). The results of the bivariate analysis showed that the relationship between low fiber consumption and the incidence of hypercholesterolemia had a PR value = 2.42 and a 95% CI (95% confidence interval) = 1.33–4.43 ( $p$ -value = 0.002). Based on the results of the analysis, it can be concluded that people with low fiber consumption ( $< 25$  grams/day) have a 2.42 times greater risk of developing hypercholesterolemia compared to people with moderate fiber consumption ( $\geq 25$  grams/day).

According to Emy Yuliantini's research results (2016), there is a correlation between fiber consumption, potassium consumption and LDL cholesterol levels where the results of the correlation coefficient are -0.363 and -0.449, respectively, these results indicate a negative relationship, so it can be predicted that if consumption increased fiber and potassium, it will be followed by a decrease in LDL cholesterol levels.

According to the results of Ayu Pertiwi's research (2020) which shows that out of 5 respondents (11.9%) have high cholesterol, 4 respondents (16.7%) have infrequent consumption, and 1 respondent (5.6%) with high cholesterol levels has high cholesterol. frequent consumption frequency. While 37 respondents (88.1%) had normal cholesterol levels, 20 respondents (83.3%) had a frequency of infrequent consumption, and 17 respondents (94.4%) with normal cholesterol levels had a frequency of

frequent consumption. Fisher exact test obtained p value (0.37) which means greater than (0.05) so  $H_a$  is rejected and  $H_0$  is accepted. Thus there is no relationship between fiber intake and cholesterol levels.

According to the results of research by Alpinia S. Pondagitan (2020) it shows that of 94.8% of respondents have less fiber intake and 5.2% of respondents have sufficient fiber intake with a minimum fiber intake of 5.3 g, maximum 53.6 g, average 17.111 g SD  $\pm$  7.540. A total of 96.3% of respondents had more fat intake, and 3.7% of respondents had sufficient fat intake with a minimum fat intake of 42.2 g, a maximum of 271.3 g, an average of 138.069 g SD  $\pm$  40.4798. Based on nutritional status, 6.7% underweight, 71.9% normal, 11.1% overweight, 10.4% obese with a minimum BMI value of 15.90 kg/m<sup>2</sup>, maximum 39.14 kg/m<sup>2</sup>, average 22.817 kg /m<sup>2</sup> SD  $\pm$  4,567. Based on total cholesterol levels, 34.1% of respondents were classified as normal, 33.3% classified as high with a minimum value of total cholesterol levels of 117 mg/dL, maximum 277 mg/dL, average 185.68 mg/dL SD  $\pm$ 32.730. The results of correlation analysis using the Pearson test found that fiber intake was positively correlated with total cholesterol levels ( $p = 0.020$ ;  $R = 0.199$ ).

According to the results of research by Alodia Yoeantafara (2017), the variable relationship between a high-fiber diet and total cholesterol levels shows that most respondents who have high total cholesterol levels are those who have a high-fiber diet in the rare category (75%). Based on the results of the chi-square statistical test, the value of  $p=0.030$  ( $p < \alpha$ ) means that there is a relationship between a high-fiber diet and total cholesterol levels. For the results of the calculation of the magnitude of the risk, an OR of 4 is obtained with a 95% CI value of  $1.28 < OR < 12.4$ . The OR value does not exceed 1 indicates that the OR value is statistically significant so that there is a significant risk difference between the group of respondents who have a high-fiber diet in the frequent category and the group of respondents who have a high-fiber diet in the infrequent category. Having a high-fiber diet in the rare category has 4 times the risk of having high cholesterol levels compared to respondents who have a high-fiber diet in the frequent category.

According to the results of Widya Aris Anggoro Wati's research (2019), it showed that the provision of smoothies with a combination of various fruits and vegetables for 21 days showed a significant difference in total cholesterol levels between the treatment group and the intervention group before and after the intervention ( $p=0.01$ ) with a difference of 33 mg decrease. /dl. Fiber intake ( $p=0.011$ ) and carbohydrate intake ( $p=0.019$ ) had an effect on decreasing total cholesterol levels.

According to the results of the Quan Zhou (2015) study, there is a responsive relationship between increased dietary fiber intake and increased HDL cholesterol in male workers. There was also a dose-response relationship between an increase in dietary fiber intake and a decrease in the ratio of total cholesterol to LDL cholesterol (in male and female workers, after adjusting for potential confounders ( $p$  for trend, all  $p < 0.05$ ). When dietary fiber intake was averaged mean increased from less than 25g/day to more than 30g/day, mean LDL cholesterol level decreased by 10.1%, and TC/LDL-C ratio decreased by 14.4% for men ( $p = 0.020$ ) and by 11. 1% for women ( $p = 0.048$ ).

The results of research by Sunni L (2010) show that the predicted mean values are based on a linear mixed effects model with random intersections, adjusted for age, body mass index, and total energy intake, and according to the total effect. (P values for the overall difference between high and low fiber intake throughout the menstrual cycle were 0.01 for total cholesterol, 0.005 for LDL cholesterol, 0.7 for HDL cholesterol, and 0.5 for triglycerides).

Adequate fiber intake is very necessary in reducing LDL cholesterol levels, the average Indonesian society eating pattern of fiber consumption is less than the normal number, which is  $< 25$ gr/day. Several types of fruits and vegetables that contain fiber such as carrots, kale, broccoli, pumpkin, corn, cabbage, spinach leaves, potatoes, kidney beans, soybeans, peanuts, grapes, avocados, apples, star fruit, melons, etc. Fruits and vegetables contain cellulose fiber, hemicellulose substance and glycoprotein, while in seeds contain cellulose fiber, hemicellulose, pectate and glycoprotein substances which have an effect on the process of reducing LDL cholesterol levels. Soluble fiber traps fat in the small intestine, so fiber can lower blood cholesterol levels by 5% or more. In the digestive tract, fiber can bind to bile salts (the end product of cholesterol) and then excreted together with feces. Thus dietary

fiber is able to reduce cholesterol levels in blood plasma so that it is expected to reduce and prevent the risk of cardiovascular disease (Anik Herminingsih, 2010).

Several researchers conducted research using the Food Recall 24 Hour questionnaire which was considered effective in conducting interventions. In this questionnaire, it can be seen that every 1 gram increase in fiber intake per day will be followed by a decrease in LDL cholesterol levels of 0.003 mg/dL. Epidemiological studies report that consuming 25 grams of fiber per 1000 kcal or 30 grams for women and men can reduce LDL cholesterol levels. After 4 weeks, there was a significant decrease in levels of Low-Density Lipoprotein Cholesterol (LDL-C) (Veronese, 2018).

#### IV. DISCUSSION

Based on 10 review journals conducted by several previous researchers, it shows that consuming high fiber can affect the reduction of cholesterol levels in the blood. A high-fiber diet is a type of food and drink containing fiber that the body consumes every day and is useful for the digestive system. Besides being useful for the digestive system, fiber consumption can prevent various dangerous diseases. While cholesterol is a fatty substance circulating in the blood, yellowish in color and in the form of a wax, which is produced by the liver and is needed by the body. Cholesterol is a non-hydrolyzed lipid group and is the main sterol in human tissues. The content of fiber intake includes sources. Fiber forms gelatin and passes through digestion to bind bile acids and bind cholesterol which is then excreted through the feces. Withdrawing cholesterol out of the digestive tract causes cholesterol levels that enter the blood to decrease. Therefore, consuming fiber regularly can reduce cholesterol levels by 15-19% (Selly Shinta Dewi, 2015).

In addition, fiber intake can also inhibit cholesterol synthesis so that it can reduce serum cholesterol concentrations by increasing the production of short chain fatty acids and bile excretion, reducing body weight by regulating energy intake, and slowing glucose absorption so as to increase insulin sensitivity. In this study, it was found that fiber intake was positively correlated with total cholesterol levels (Soliman GA, 2019).

Meanwhile, according to Ira (2014) a high-fiber diet shows a relationship between a high-fiber diet and total cholesterol levels which are shown based on the results of statistical analysis, namely  $p = 0.030$  ( $p > 0.05$ ) with a large risk of  $OR = 4$ . This is supported by a Randomized Controlled Trial (RCT) study conducted at Beijing Hospital, China, in patients with hypercholesterolemia, proving that giving 100 grams of oat cereal for 6 weeks can reduce LDL cholesterol levels by 8.4 percent compared to the control group (3.5%) (Zhang J, 2012).

A double-blind randomized crossover study on 17 college students at the Chopenhagen campus in 3 different treatment groups for 7 days found that compared to the control group (a low-fiber diet), flaxseed drink (3 times/day) could reduce total blood sugar levels, cholesterol and LDL cholesterol by 12 and 15 percent, respectively, compared to the group receiving flaxseed bread (3 times/day) of 7 and 9 percent, respectively. Research on 39 adult men in Mexico in the group that received a diet high in dietary fiber (48 grams/day) for 7 days had a negative relationship with LDL cholesterol levels ( $r = -0.34$ ,  $p < 0.03$ ) compared to the group. diet low in dietary fiber (27gram/day) (King DE, 2012).

By consuming dietary fiber  $< 25$  grams/day, most (78.3%) had high LDL cholesterol levels and only 21.7 percent had normal LDL cholesterol levels. This has actually shown that dietary fiber intake has a role in lowering LDL cholesterol. However, statistically it cannot be proven because all respondents consume less dietary fiber than recommended. There are several factors that cannot be controlled, namely genetics, age and gender. High cholesterol levels can be prevented by diet by reducing saturated fat and cholesterol from food.

According to the results of research conducted by Emy Yuliantini (2014) With the results of statistical tests, it was found that there was a significant relationship using the Pearson Correlation. Consumption of fiber with LDL cholesterol levels showed a moderate relationship, meaning that the lower the consumption of fiber, the higher the value of LDL cholesterol levels. Insufficient fiber intake can result in less bile acids in emulsifying fat into feces. So that LDL cholesterol levels in the blood can

increase. Fiber is found in fruits, vegetables and some types of legumes. The fiber dissolves and forms a gel in water. The formation of this gel in the digestive tract causes the speed to slow down in pushing food components into the intestine, thereby slowing the absorption of cholesterol and other fats, resulting in an increase in the production of short chain fatty acids by fermentation.

According to the results of research by Ighosotu and Tonukari (2010), which showed that the group of respondents who had a low fiber intake had a higher lipid profile (total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, and the ratio of total cholesterol to HDL cholesterol). Research conducted by Yuliantini (2015) also states the same thing, there is a relationship between fiber intake and total cholesterol levels because the mechanism of fiber has the property of lowering blood cholesterol. Fiber forms gelatin and passes through digestion to bind bile acids and bind cholesterol which is then excreted through the feces. Withdrawing cholesterol out of the digestive tract causes cholesterol levels that enter the blood to decrease. Therefore, consuming fiber regularly can reduce cholesterol levels by 15-19%.

In this study, the relationship between dietary fiber intake and LDL cholesterol levels in Kebon Kalapa Village was influenced by age category factors that had a greater risk of suffering from hypercholesterolemia, which was more than 45 years. Some experts argue that the older a person, the less the ability of his LDL receptors. While the LDL receptor is an inhibiting factor (inhibitor) of cholesterol synthesis in the body. That is, decreased LDL receptor activity due to increasing age will cause cholesterol synthesis to increase so that total cholesterol levels are high (Yunita, 2014).

Based on the results of research by Widya Aris Anggoro Wati (2019), the decrease in cholesterol levels in the combination of fruit and vegetable smoothies contains substances that can reduce total cholesterol levels such as anthocyanins, lycopene, niacin, vitamin C, flavonoids, PUFA, MUFA and water soluble fiber. Research by Rakhmiditya and Kartini (2014) showed that 8.01 mg of anthocyanin can reduce cholesterol levels by 56 mg/dl ( $p < 0.05$ ). Yunita's research (2010) showed that giving 6 grams of fiber for 14 days could reduce 18 mg/dl of total cholesterol ( $p > 0.05$ ). In a study conducted, the level of fiber adequacy has an effect on reducing total cholesterol levels. This is in line with the theory of fiber lowering cholesterol by preventing cholesterol synthesis from occurring at the stage of inhibiting the activity of the HMG-co A reductase enzyme. Another mechanism for lowering cholesterol in the body is an increase in bile secretion and an increase in cholesterol excretion from food intake. Waloya's research (2013) showed that the level of fiber adequacy had an effect on reducing total blood cholesterol levels ( $p = 0.001$ ).

Based on the 10 journals above, it can be concluded that consuming foods high in fiber 25-30 g/day is associated with a decrease in LDL cholesterol levels. The American Heart Association (AHA) recommends increasing fiber intake by 25 to 30 g/day to lower lipids, especially in reducing LDL levels in the blood. By consuming fruits and vegetables such as kale, broccoli, mustard greens, papaya leaves, avocados, melons, etc., 25 grams/day can reduce LDL cholesterol levels by 15 to 19% and can reduce the risk of heart disease by more than 30%. (Kristensen M et al, 2012). Therefore, researchers expect respondents to regularly consume fiber-containing foods such as legumes, vegetables (carrots, tomatoes, cucumbers, spinach, kale, lettuce, long beans, eggplant and cassava leaves), and fruits. bananas, salak, oranges, apples, papaya, pineapple, mango) and regularly check cholesterol levels.

Adequate level of fiber affects the reduction of LDL cholesterol levels. Several types of food ingredients such as vegetables and fruits contain fiber that can reduce LDL cholesterol levels such as cellulose fiber, hemicellulose and glycoprotein substances, pectats, phenolic esters, galactomannan, guar gum, arabic gum, alginate gum, carrageenan, xanthan gum, modified cellulose, modified starch, etc. The pattern of fiber consumption by using a 24-hour food recall questionnaire is expected to be an effective way to control our daily consumption of dietary fiber. Food fiber in addition to having a positive effect on health, it also has a negative effect, so that dietary fiber should not be consumed in excess and as a reference the recommended fiber requirement is a maximum of 30 grams / day. In the case of DM patients, it should not be more than 25 grams/day while in CHD patients the maximum is 30 grams/day. Most Indonesian people do not pay much attention to diet so that some of them experience

hypercholesterolemia and even experience CHD. With the above discussion, it is hoped that the public will know the benefits of consuming foods that contain fiber and can also reduce the highest number of deaths due to hypercholesterolemia

## V. CONCLUSION

Fiber intake is one of the vegetable food ingredients that can be consumed and can be absorbed by the small intestine and undergoes fermentation throughout the small intestine. The American Heart Association (AHA) recommends increasing fiber intake by 25 to 30 g/day to lower lipids, especially in reducing LDL levels in the blood. HMG-CoA Reductase. This enzyme plays a role in the formation of mevalonate which is the main product in the formation of cholesterol. By inhibiting the activity of the enzyme HMG-Co A Reductase, mevalonate is not formed so that cholesterol is not formed. Dietary fiber increases the enzymatic activity of cholesterol-7- $\alpha$ -hydroxylase, the main enzyme in the hepatic conversion of cholesterol to bile acids that contributes to the breakdown of liver cholesterol.

By consuming a variety of fruits and vegetables at 25 g / day can reduce LDL cholesterol levels by 15-19%. According to the Indonesian Food Composition (TKPI) in 2017, good fiber consumption for people with diabetes mellitus ranges from 20-35 grams/day with the recommended fiber consumption of 25 grams/day has been categorized into adequate fiber intake. Meanwhile, according to PERKI (Indonesian Cardiology Association) recommends 25-30 g/day for heart and blood vessel health. Fiber consumption must be balanced with water consumption to avoid digestive disorders, including constipation. Several studies have shown that age is one of the factors for the occurrence of hypercholesterolemia. Men over the age of 45 are at risk for high cholesterol and women will experience hypercholesterolemia at the age of menopause because at the time of menopause, the hormone estrogen will decrease..

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