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EFFECTS OF VIRGIN COCONUT OIL SUPPLEMENTATION ON BIOMARKERS OF OXIDATIVE STRESS IN OBESE ADOLESCENTS

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ABSTRACT

Obesity in adolescents is a health problem whose prevalence is closely related to increased oxidative stress. Obesity conditions lead to increased production of reactive oxygen species (ROS) which can trigger lipid peroxidation, cell damage, and various metabolic disorders. Biomarkers of oxidative stress, such as malondialdehyde (MDA) levels and the activity of antioxidant enzymes, namely superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase (CAT), can be used to assess oxidative stress levels in obese individuals. Virgin Coconut Oil (VCO) is a functional food that contains medium-chain fatty acids (medium-chain triglycerides; MCTs) and phenolic compounds that are thought to have antioxidant and anti-inflammatory activity. The study aimed to analyze the effect of Virgin Coconut Oil supplementation on biomarkers of oxidative stress in obese adolescents. This study uses a quasi-experimental pretest-posttest control group design. A total of 40 obese adolescents aged 15–18 years were

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divided into two groups, namely the treatment group that received VCO supplementation of 15 mL per day for 8 weeks and the control group that received only balanced nutrition education. The results indicate that VCO supplementation has the potential to increase the body's antioxidant capacity and reduce oxidative stress in obese adolescents. Although the decrease in BMI and waist circumference did not show a statistically significant difference, there was a tendency to improve the anthropometric profile in the group receiving VCO.

INTRODUCTION

Obesity in adolescents has become one of the most serious public health problems in the world (1), (2). The increase in the prevalence of obesity in the adolescent age group occurs not only in developed countries, but also in developing countries, including Indonesia (3). Adolescence is a critical period characterized by rapid growth and development, so impaired nutritional status in this phase can have a long-term impact on health (4). Adolescents with obesity have a higher risk of developing various non-communicable diseases in adulthood, such as type 2 diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, and metabolic syndrome.

Pathophysiologically, obesity is characterized by an excessive accumulation of adipose tissue. Adipose tissue is no longer seen only as a store of energy, but also as an active endocrine organ that produces various proinflammatory and adipokine mediators (5). Increased fat mass, especially visceral fat, can cause low-grade chronic inflammation that triggers an increase in the production of reactive oxygen species (ROS). If the amount of ROS exceeds the capacity of the body's antioxidant defense system, a condition known as oxidative stress will occur.

Oxidative stress plays an important role in the development of metabolic complications in obesity. Excessive production of ROS can result in damage to lipids, proteins, and cellular DNA through the oxidation process. One of the most widely used indicators to measure lipid peroxidation is malondialdehyde (MDA) levels. Increased MDA levels have been reported to be associated with degrees of obesity, insulin resistance, and an increased risk of cardiometabolic disease. In contrast, the body has an endogenous antioxidant system consisting of various enzymes, such as superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase (CAT), which function to neutralize free radicals and maintain cellular redox balance. In obese individuals, the activity of these antioxidant enzymes often decreases, worsening oxidative stress conditions.

Various nutritional intervention strategies have been developed to reduce oxidative stress in obese individuals, one of which is through the use of functional foods that have antioxidant activity. Virgin Coconut Oil (VCO) is a natural product obtained from fresh coconut meat without high heating and without the use of chemicals. VCO contains medium-chain fatty acids (MCTs), especially lauric acid, caprylic acid, and capric acid, and contains bioactive compounds in the form of polyphenols and tocopherols in certain amounts. These ingredients are thought to play a role in increasing the body's antioxidant capacity, reducing inflammation, and improving lipid metabolism.

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Several studies have shown that VCO administration can increase antioxidant enzyme activity and decrease lipid peroxidation biomarkers in animal models that experience inflammatory conditions and oxidative stress. In addition, VCO consumption has also been reported to improve lipid profiles and improve insulin sensitivity through the mechanism of increasing fatty acid oxidation and modulating the inflammatory response. However, scientific evidence regarding the effects of VCO supplementation on biomarkers of oxidative stress in obese adolescents is limited,(6) especially in the adolescent population in Indonesia. Most previous studies have been conducted in experimental animals or adult populations, so the results cannot be generalized to adolescent age groups.

Obese adolescents are a group that is prone to experiencing increased oxidative stress due to hormonal changes (7), A diet high in energy, low consumption of antioxidants, and low physical activity. Therefore, research is needed to examine local food-based interventions that are safe, easy to obtain, and have potential as natural antioxidants. VCO(8), (9), as one of the abundant coconut derivative products in Indonesia, it has the potential to be developed as a functional food to help reduce oxidative stress in obese adolescents (10), (11).

Based on this description, this study aims to analyze the effect of Virgin Coconut Oil supplementation on biomarkers of oxidative stress in obese adolescents, which is measured through changes in MDA levels as well as the activity of antioxidant enzymes SOD, GPx, and CAT. The results of this study are expected to provide a scientific basis for the use of VCO as a local food-based nutrition intervention in an effort to prevent metabolic complications in obese adolescents and enrich studies in the field of Nutritional Biochemistry (Nutritional Biochemistry).

This study is novel because it evaluates the effect of Virgin Coconut Oil supplementation on oxidative stress biomarkers in obese adolescents, a population that is still rarely studied, using a combination of lipid peroxidation biomarkers (MDA) and endogenous antioxidant enzymes (SOD, GPx, and CAT). In addition, this study examines the potential of VCO as a functional food based on Indonesian local resources in the biochemical approach of nutrition and the prevention of metabolic diseases.

RESEARCH METHODS

Research Design

The population in this study was all adolescents aged 15–18 years who were obese

Criteria including:

1. Suffering from chronic diseases such as diabetes mellitus, kidney disease, liver disease, or endocrine disorders.
2. Had an acute infection during the study.
3. Have an allergy to coconut products.
4. Not following the entire series of research until it is finished.

The sample size is determined using the two-mean difference test formula:

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n=2(Zα/2+Zβ)2σ2

with:

- Zα/2=1,96Z_{\alpha/2}=1,96Zα/2=1,96 (95% confidence level);
- Zβ=0,84Z_{\beta}=0,84Zβ=0,84 (80% research power);
- σ\sigmaσ = standard deviation of MDA levels based on previous research;

1. (μ1−μ2)(\mu_1-\mu_2)(μ1−μ2) = the difference in the expected average level of MDA.

Based on calculations, a minimum sample of 20 respondents was obtained in each group. Taking into account a drop out of 10%, the number of samples recruited was 44 respondents, which were divided into 22 treatment group respondents and 22 control group respondents.

Sampling Techniques

Sampling was carried out using the purposive sampling technique, which is the selection of respondents based on the inclusion and exclusion criteria that have been set.

Research Procedure

Respondents who met the criteria were divided into two groups, namely:

1. **The treatment group** was given 15 mL of *Virgin Coconut Oil* (VCO) supplementation per day for eight weeks.
2. **The control group** was given balanced nutrition education without the administration of VCO supplements.

During the study, all respondents were asked to maintain their usual diet and physical activity.

Anthropometric Measurements

Weight

Weight was measured using a digital scale with an accuracy of 0.1 kg.

Height

Height was measured using *microtoise* with an accuracy of 0.1 cm.

Body Mass Index (BMI)

Body Mass Index is calculated by the formula:

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BMI=Weight (kg)Height (m)2IMT=\frac{Weight\ body\ (kg)}{Height\ body\ (m)^2}IMT=Height (m)2Weight (kg)

Waist circumference

Waist circumference was measured using a nonelastic tape measure with an accuracy of 0.1 cm.

Food Intake Measurement

The food intake of the respondents was assessed using:

1. *Food Recall* 2 × 24 hours (weekdays and holidays).
2. *Food Frequency Questionnaire* (FFQ).

The data obtained was analyzed to find out:

1. Energy intake;
2. Carbohydrate intake;
3. Asupan protein;
4. Fat intake;
5. Asupan vitamin C;
6. Vitamin E.

Oxidative Stress Biomarker Examination

Blood Sampling

A total of 5 mL of venous blood was taken after respondents fasted for 10–12 hours. The blood sample was then centrifuged at 3000 rpm for 15 minutes to obtain serum and plasma, then stored at −80°C until the examination was carried out.

Malondialdehyde (MDA) Level Check

MDA levels were checked using **the Thiobarbituric Acid Reactive Substances (TBARS)** method. The principle of examination is a reaction between MDA and thiobarbiturate acid that produces a pink complex and is measured using a spectrophotometer at a wavelength of 532 nm. The results are expressed in units of nmol/mL.

Superoxide Dismutase (SOD) Activity Check

SOD activity was checked using **the Enzyme-Linked Immunosorbent Assay (ELISA)** method and expressed in units of U/mL.

Glutathione Peroxidase (GPx) Activity Check

GPx activity was checked using the ELISA method and expressed in U/L units.

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Catalase Activity Check (CAT)

CAT activity was examined using the colorimetric method and expressed in units of U/mL

Data Analysis

Data were analyzed using **the IBM SPSS Statistics program version 26**.

The stages of analysis include:

1. **Univariate analysis**, to describe the characteristics of respondents presented in the form of averages, standard deviations, frequencies, and percentages.
2. **The data normality test** was carried out, using the Shapiro-Wilk test.
3. **Bivariate analysis**, including:
    1. *Paired t-test* to find out the differences before and after the intervention in each group.
    2. *Independent t-test* to find out the difference between the treatment group and the control group.
4. **Multivariate analysis**, using **Analysis of Covariance (ANCOVA)** to control for confounding variables, such as age, gender, energy intake, and physical activity.

A **p< value of 0.05** is considered statistically significant.

RESULTS AND DISCUSSION

RESULTS

Respondent Characteristics

A total of **44 obese adolescents** participated in the study, consisting of 22 respondents in the VCO group and 22 respondents in the control group. There was no significant difference in the initial characteristics of the two groups (p>0.05).

Table 1. Characteristics of Respondents at the Beginning of the Study

Variabel	Variabel VCO (n=22)	Control Group (n=22)	p-value
Age (years)	16,5 ± 1,1	16,3 ± 1,0	0,534
Male (%)	54,5	50,0	0,765
IMT (kg/m²)	31,2 ± 2,8	30,8 ± 2,6	0,624
Waist Circumference (cm)	95,8 ± 7,2	94,9 ± 6,8	0,681

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Both groups have homogeneous basic characteristics so that they can be compared

Changes in Oxidative Stress Biomarkers

Table 2. Changes in Biomarkers of Oxidative Stress Before and After Intervention

Variabel	Before	After	p-value
VCO Group			
MDA (nmol/mL)	5,82 ± 0,84	4,31 ± 0,71	<0,001
SOD (U/mL)	1,78 ± 0,34	2,45 ± 0,42	<0,001
GPx (U/L)	38,5 ± 6,4	47,8 ± 7,1	<0,001
CAT (U/mL)	40,2 ± 5,8	49,6 ± 6,5	<0,001
Control Group			
MDA (nmol/mL)	5,74 ± 0,80	5,60 ± 0,79	0,416
SOD (U/mL)	1,80 ± 0,31	1,87 ± 0,35	0,378
GPx (U/L)	39,1 ± 6,1	40,2 ± 6,3	0,491
CAT (U/mL)	39,8 ± 5,9	40,6 ± 6,1	0,583

Intergroup Analysis After Intervention

Table 3. Differences in Oxidative Stress Biomarkers After Eight Week

Variabel	VCO Group	Control Group	p-value
MDA (nmol/mL)	4,31 ± 0,71	5,60 ± 0,79	<0,001
SOD (U/mL)	2,45 ± 0,42	1,87 ± 0,35	<0,001
GPx (U/L)	47,8 ± 7,1	40,2 ± 6,3	<0,001
CAT (U/mL)	49,6 ± 6,5	40,6 ± 6,1	<0,001

The results showed that **Virgin Coconut Oil (VCO) supplementation of 15 mL/day for eight weeks** had a significant effect on biomarkers of oxidative stress in obese adolescents. The group that received VCO experienced a decrease in MDA levels by **25.9%**

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compared to the baseline value ($p<0.001$). In addition, there was an increase in antioxidant enzyme activity, namely SOD by **37.6%,** GPx by **24.2%,** and CAT by **23.4%** ($p<0.001$).

In contrast, the control group showed no significant changes in all oxidative stress biomarkers ($p>0.05$). *Independent t-test* analysis showed that after intervention there was a significant difference between the VCO group and the control group in MDA, SOD, GPx, and CAT levels ($p<0.001$).

This study indicates that VCO supplementation has the potential to improve antioxidant status and reduce oxidative stress in obese adolescents

DISCUSSION

Decreased MDA levels in the VCO group showed a reduction in lipid peroxidation processes which is one of the main indicators of oxidative stress in obesity. The content of *medium-chain fatty acids* (MCTs) and phenolic compounds in VCO is thought to play a role in suppressing ROS formation and boosting the endogenous antioxidant defense system.

Increased SOD, GPx, and CAT activity suggests that VCO supplementation can increase the body's antioxidant capacity. These enzymes function to convert free radicals into more stable compounds thereby reducing oxidative damage to lipids, proteins, and DNA. These results support the potential of VCO as a functional food that can be used as a nutritional intervention in obese adolescents.

CONCLUSION

Suplementasi **Virgin Coconut Oil (VCO) sebanyak 15 mL/hari selama delapan minggu** berpengaruh signifikan terhadap biomarker stres oksidatif pada remaja obesitas. Pemberian VCO menurunkan kadar **Malondialdehyde (MDA)** serta meningkatkan aktivitas enzim antioksidan **Superoxide Dismutase (SOD), Glutathione Peroxidase (GPx), dan Catalase (CAT)** dibandingkan kelompok kontrol.

These findings suggest that VCO has the potential to be developed as **a functional food based on local Indonesian resources** that can help reduce oxidative stress and lower the risk of metabolic complications in obese adolescents.

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