ORIGINAL RESEARCH REPORT

Effect of Virgin Coconut Oil Supplementation on AFB Sputum Conversion Rate, SOD, and BMI Levels in Pulmonary Tuberculosis Patients

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ABSTRACT

Background: Pulmonary tuberculosis has the potential to raise illness and death rates on a global scale significantly. A low sputum conversion rate for acid-fast bacilli (AFB) and malnutrition are indicators of failure in pulmonary TB treatment. Virgin coconut oil (VCO) contains lauric acid and has antibacterial, antioxidant, and anti-inflammatory effects. **Objective:** This study aimed to examine the effect of VCO supplementation on sputum AFB conversion rates, superoxide dismutase (SOD) levels, and body mass index (BMI) status of pulmonary TB patients. **Material and Methods:** This study was an analytic experimental study measuring BMI levels and SOD levels at the Pekauman Community Health Center, Sultan Suriansyah Hospital, and Ulin Hospital, Banjarmasin, Indonesia, between July and September 2023. This study, 40 samples were separated into two groups: the treatment group, which received first-line antithyroid drugs (ATD) with VCO, and the control group, which received first-line ATD and a placebo. **Results:** Based on the proportion, there was an improvement in the acceleration of BTA sputum conversion, and from the mean BMI and the median value of both groups, there was a decrease in SOD levels after VCO administration. No statistically significant association was found between VCO administration and accelerating the AFB sputum conversion and BMI at the end of the fourth and eighth weeks ($p>0.05$). Additionally, there was no relationship considered between VCO administration and reducing SOD levels before and after treatment ($p>0.05$). **Conclusion:** VCO administration had no relationship with the level of AFB sputum conversion, reduction in SOD levels, and BMI status in pulmonary TB patients.

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Highlights

1. VCO can accelerate AFB sputum conversion in tuberculosis infection.
2. VCO can decrease SOD levels as a marker of inflammation.

BACKGROUND

Tuberculosis (TB) has existed for thousands of years but remains a significant health issue in most countries with low incomes. The World Health Organization (WHO) reported 10.6 million new cases of tuberculosis in 2021, an increase of 600,000 cases from 2020, which was anticipated to be 10 million cases, with a mortality rate of more than 1.6 million (World Health Organization, 2022). Indonesia has the highest prevalence of TB cases among all countries. The country ranks second globally with a total of 969,000 cases and an incidence rate of 354 cases per 100,000 population (Firdaus, et al., 2023). In 2022, the South Kalimantan Provincial Health Service recorded a total of 7556 cases, out of which 3861 (51%) were confirmed to be positive for acid-fast bacilli (AFB) in sputum samples. Among these cases, Banjarmasin City accounted for 1768 cases, with 819 (46%) being positive for AFB sputum (Sukarli & Mahdani, 2023).

The high mortality rate resulting from failure to treat pulmonary TB is a concern. An important thing in evaluating treatment is assessing the conversion of AFB sputum. Sputum conversion in pulmonary TB cases occurs at the end of the first month (60-80%) and at the second month (95%). However, around 9% of cases do not experience sputum conversion (Aliyah, et al., 2016). AFB sputum conversion is a guideline for determining treatment success with a minimum rate of 80% (Mahendrani, et al., 2020).

Virgin coconut oil (VCO) has gained significant popularity and is extensively advocated and utilized for its health benefits. Coconut oil can also be referred to as tropical oil or lauric oil. VCO is natural oil due to its production procedure, which does not include heating. VCO possesses antibacterial, antioxidant, and anti-inflammatory properties (Bhatt, et al., 2021; Mela & Bintang, 2021). Nutritional status is also a determining factor in the success of pulmonary tuberculosis treatment based on measuring body mass index (BMI). The sputum conversion rate in patients with a BMI <18.5 kg/m^2 was lower than in patients with a BMI >18.5 kg/m^2 (Sari, et al., 2019).

The efficacy of therapy is also impacted by internal factors, one of which is oxidative stress (SO). SO occurs due to an imbalance between free reactive oxygen species (ROS) and antioxidant mechanisms, which play a crucial role in the inflammatory process in TB patients. Pulmonary tuberculosis carries a significantly higher chance of developing significant organ damage compared to other organs (Shastri, et al., 2018). Antioxidants in VCO, such as polyphenols, have been studied to prevent and treat diseases caused by oxidative damage. This polyphenol content can increase endogenous antioxidants, the SOD (Ighodaro & Akinloye, 2018).

OBJECTIVE

The main objective of this research was to determine the effects of VCO supplementation on sputum AFB conversion, SOD levels, and BMI in patients with pulmonary tuberculosis. The primary objective of this study was to examine the differences in AFB seroconversion, SOD level, and BMI following the administration of VCO supplementation at the end of the 4^{th} and 8^{th} week of the intervention.

MATERIAL AND METHOD

This study was analytic experimental research conducted on TB patients who were confirmed bacteriologically by examination of sputum AFB and TCM, SOD, and BMI levels at the Pekauman Community Health Center, Sultan Suriansyah Regional Hospital, and Ulin Regional Hospital, Banjarmasin, Indonesia. The research samples were all pulmonary TB patients diagnosed bacteriologically with positive AFB sputum and TCM MTb detected sensitive rifampicin who were examined and treated at the Pekauman Community Health Center, Sultan Suriansyah Regional Hospital and Ulin General Hospital Banjarmasin from July to September 2023, based on specific inclusion and exclusion criteria.

Inclusion criteria for this study included patients who were over 18 years of age and had signed informed consent, patients who were diagnosed with pulmonary TB based on positive AFB sputum results and sensitive rifampicin-detected TCM MTb who had not undergone first-line ATD treatment, TB patients were domiciled in the city of Banjarmasin, TB patients body weight and body height.

Exclusion criteria in this study were domiciled outside Banjarmasin, the patients who had undergone TB treatment for less than one month, patients who did not follow the research protocol in an orderly way, and patients who experienced severe side effects.

Sampling technique

The research sample was selected using simple random sampling in compliance with the inclusion and exclusion criteria. The study's sample was divided into two groups: patients receiving first-line ATD as a placebo control and those receiving first-line ATD with a dose of 1x30 ml VCO as the treatment group. The research was comparative analytic research using an unpaired numerical measurement scale from Dahlan, (2011):

$$S^n = \frac{S_1^2(n_1 - 1) + S_2^2(n_2 - 1)}{(n_1 + n_2 - 2)}$$

Legend:

N_1 = first group based on literature.
N_2 = second group based on literature.
S_1 = Group one standard deviation based on literature.
S_2 = Group two standard deviation based on literature

$$S^2 = \frac{S_1^2(n_1-1)+ S_2^2(n_2-1)}{n_1 + n_2 - 2}$$
$$S^2 = \frac{4^2(20-1)+6^2(20-1)}{20 + 20 - 2}$$
$$S^2 = \frac{16(19)+36(19)}{38}$$
$$S^2 = \frac{304+684}{38}$$
$$S^2 = \frac{988}{38}$$
$$S^2 = 26$$
$$S = \sqrt{26}$$
$$S = 5{,}09$$

So, the sample size is calculated using the formula above, using a hypothetical 5% alpha.

The research instruments were informed consent, a blood chemistry tube, a 3-cc injection syringe (One Med), a cooling box, a fridge or freezer, an Eppendorf 5702 brand centrifuge, sputum pot, glass objects, Ziehl Nielsen staining (Bio Analitika-3729298000-AL2-119592672), a spiritus lamp, a light microscope (Mikroskop Cahaya-3899601999-PP2-194217438), scales and meters (GEA), and liquid VCO (VCO TJ PT. Byhaf).

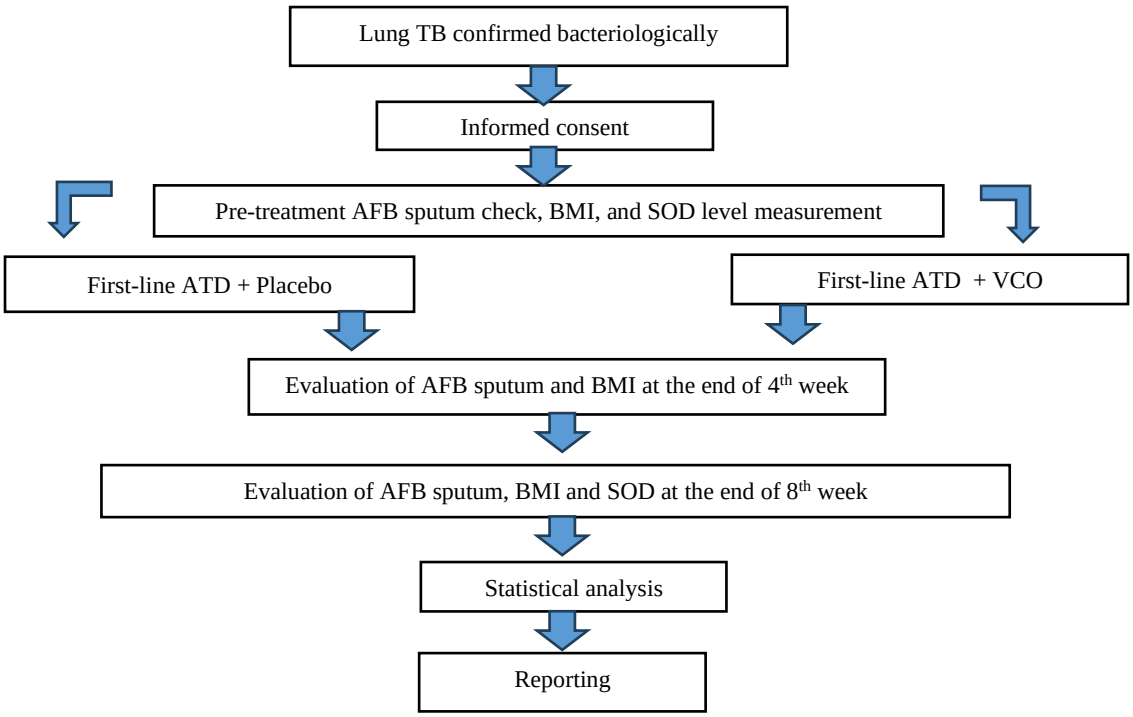

Figure 1. Flow chart of the research.

Patients who were suspected of having pulmonary tuberculosis were evaluated for AFB and TCM. If TCM MTb is detected and AFB is positive, it was included in the examined sample group. Afterward, informed consent was provided. The patients provided blood samples of 3 cc each, which were then subjected to centrifugation to separate the serum. The obtained serum was after that sent to the Banjarbaru biochemistry laboratory to measure the SOD levels. Then, the patients had a weight and height measurement to asses their Body Mass Index (BMI). During therapy for pulmonary tuberculosis, the patients were administered 30 cc of VCO daily for two months. The BW and height examination was conducted at the end of the first month of TB treatment and additional VCO supplementation. At the end of the second month, the patients were examined for BTA sputum, blood BW, and height. A 3cc blood sample was taken from the fold of the arm, and the serum was taken to check the SOD levels at the Banjarbaru biochemistry laboratory. Then, the data were subjected to statistical analysis, and a report was made.

Data analysis

The data were analyzed using the IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). The data had previously been tested for homogeneity and normality. The initial data were analyzed using univariate analysis, which used descriptive statistics to show normally distributed values as mean and standard deviation and non-normally distributed values as median and range. Bivariate analysis was conducted utilizing parametric tests and the independent t-test to quantify SOD and BMI levels. The Mann-Whitney test was employed when the data distribution was not normal ($p< 0,05$). The Chi-Square test was also used to analyze sputum conversion ($p> 0,05$). Fischer exact test was employed if the expected count value was <5 and >20 ($p> 0,05$).

Ethical approval

Ethics permission was obtained with the approval and consideration of the Ethics Commission of the Faculty of Medicine, Lambung Mangkurat University (No. 314/KEPK-FK ULM/EC/X/2023) on 02-10-2023, and the Ethics Commission of the Research and Development Agency of ULIN Hospital Banjarmasin (No. 162/VII-Reg Riset/RSUDU/23) on 25-07-2023.

RESULT

Subject characteristic

Table 1 describes data on age, gender, smoking, type of cigarette, Brinkman index, length of time to stop smoking, comorbidities, occupation, body weight, nutritional status, and side effects after two months of treatment.

Table 1. Sample characteristics in treatment and control groups.

Sample characteristics		Data	
		DOTS+VCO (n=20)	DOTS+ Placebo (n=20)
Gender	Male (%)	14(70)	12(60)
	Female (%)	6(30)	8(40)
Age	18-24 (yo)	3(15)	4(20)
	25-34 (yo)	2(10)	3(15)
	35-44 (yo)	3(15)	6(30)
	45-54 (yo)	6(30)	1(5)
	>55 (yo)	6(30)	6(30)
Smoking	Smoker (%)	14(70)	12(60)
	Not smoker (%)	6(30)	8 (40)
Brinkman index	Mild (%)	6(42,8)	3(25)
	Moderate (%)	7(50)	7(58,3)
	Severe (%)	1(7,1)	2(16,6)
Comorbidities	Hypertension (%)	3(15)	2(10)
	Diabetes (%)	4(20)	5(25)
	Hypertension and diabetes (%)	2(10)	0
	COPD (%)	0	1(5)
	HIV (%)	0	1(5)
	No comorbidity (%)	11(55)	11(55)
Weight	Before treatment (mean)	45.45	50.12
	End of 4th week (mean)	47.17	51.35
	End of 8th week (mean)	49.15	53.5
Good nutrition	Before treatment (mean)	8(40)	10(50)
	End of 4th week (mean)	10(50)	10(50)
	End of 8th week (mean)	14(70)	11(55%)
Malnutrition	Before treatment (mean)	12(60)	10(50)
	End of 4th week (mean)	10(50)	10(50)
	End of 8th week (mean)	6(30)	9(45)
Side effects	Nausea	7(35)	0
	Diarrhea	2(10)	0

Legend: SD: Standard deviation.

Table 1 shows that the most common gender in the treatment and control groups is male, with 14 individuals (70%) in the treatment group and 12 individuals (70%) in the control group. Meanwhile, for age characteristics in the control group, it was found that the highest age range was 35-44 years (30%) and age >55 years (30%), while in the treatment group, the age range of 45-54 years and >55 years were dominated by 30% each.

According to smoking data history, 12 (60%) samples of the control group smoked, and 8 (40%) samples of non-smokers. Meanwhile, in the treatment group, data were obtained that 14 (70%) people smoked and 6 (30%) people did not smoke. The Brinkman index found that most of the control group were moderate smokers (58.3%), followed by light smokers (25%) and heavy smokers (16.6%). In the treatment group, it was also found that the majority were moderate smokers (50%), followed by light smokers (42.8%) and finally heavy smokers (7.1%).

In the treatment group, the most prevalent comorbidity among study subjects was diabetes mellitus (DM), with a rate of 4 people (20%). In the control group, DM occurred in 5 people (25%). Hypertension ranked second in both groups, with three people (15%) in the therapy group and two (10%) in the control group. The combined number of individuals with comorbidities in both the treatment and control groups was nine people each, accounting for 45% of the total.

Table 1 shows that the control group (first-line ATD + placebo) and the treatment group (first-line ATD + VCO) had weight gain. However, it was seen that the placebo group had a higher mean BW compared to the treatment group. In Table 1, the nutritional status of the treatment group in the good category experienced a significant increase from 8 people (40%) to 10 people (50%). At the end of the 8th week, it increased to 14 people (70%). The malnutrition category decreased significantly from 12 people (60%) to 10 people (50%) at the end of the 4th week, and also at the end of the 8th week it decreased to 6 people (30%).

The control group did not experience any adverse effects due to the placebo administration. In the meantime, the treatment group experienced two adverse effects: diarrhea and nausea. Nausea was the most prevalent adverse effect in 35% of the treatment group samples, while diarrhea was observed in 10% of the treatment group.

Table 2. BMI normality tests.

Normality test	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IMT 0	.131	40	.082	.960	40	.171*
IMT 1	.106	40	.200*	.977	40	.582*
IMT 2	.148	40	.028	.950	40	.078*
SOD 1	.210	40	<.001	.909	40	.004
SOD 2	.084	40	.200*	.970	40	.361*

Table 2 shows that the Shapiro-Wilk test is carried out for BMI status in the treatment and control groups because the sample size is <100 patients. The data before the intervention, in the first and fourth week, showed p>0.05, so the sample distribution was normal and met the requirements for the unpaired t-test to be carried out further.

The research subject data were tested for normality on SOD levels. We carried out the Shapiro-Wilk test because the sample size was <100 patients to assess the normality of data distribution. The data would be normally distributed if the significance value is (p>0.005). Based on the data from the normality test, results on SOD levels before treatment revealed p=0.004 (p<0.05), so the SOD data before treatment were not normally distributed. Whereas SOD levels after the eighth week of treatment showed p=0.361 (p>0.05), indicating normally distributed data.

Variable characteristics

The variable characteristics of this study were the AFB sputum conversion rate and changes in BMI status at the end of the 4th and 8th weeks as well as changes in SOD levels before and after eight weeks in the treatment and control groups.

Table 3 shows that ten patients (50%) in the control group who were given a placebo converted to a negative AFB sputum at the end of the 4th week, and the remaining ten patients (50%) had not experienced conversion. Meanwhile, at the end of the 8th week, 17 patients experienced negative conversions (85%), and three failed to convert (15%). In the treatment group receiving VCO, there was a conversion of AFB sputum to negative at the end of 4th week. As many as 16 patients (80%) and the remaining four (20%) had not experienced conversion. Meanwhile, at the end of the 8th week, 20 patients (100%) experienced negative conversions. Chi-square analysis of conversion status after four weeks of ATD treatment in the control group and treatment group receiving VCO supplementation (Table 2) reveals no significant difference in conversion status with p=0.110. From the results of the tabulation of the chi-square test on AFB sputum conversion at the end of the eighth week, it was found that two cells had an expected count of < 5, so a Fisher exact test was carried out, and the results were p=0.231 (p>0.05).

Table 3. Variable characteristics in treatment and control groups.

Variable characteristics		Data		p
		ATD+ VCO (n=20)	ATD+Plasebo (n=20)	
AFB sputum conversion	End of 4th week (%)	16(80)	10(50)	0.110
	End of 8th week (%)	20(100)	17(85)	0.231
BMI	Before treatment (mean±SD)	17.53±3.33	19.04±3.05	0.614
	End of 4th week (mean±SD)	18.48±3.56	19.29±3.33	0.872
	End of 8th week (mean±SD)	19.32±3.62	20.12±4.08	0.430
SOD level	Pre (median[min-max])	0.019 (0.001-0.033)	0.017 (0.003-0.03)	0.114
	Post (median[min-max])	0.013 (0.000-0.031)	0.0135 (0.000-0.025)	0.989

Legend: BMI: Body mass index; SOD: superoxide dismutase; AFB: Acid-fast bacilli; SD: Standard deviation.

SOD levels in the treatment group before treatment had a median of 0.019 (0.001-0.033) decreased to 0.013 (0.000-0.031) at the end of the 8th week. SOD levels in the control group before treatment had a median of 0.017 (0.003-0.03) decreased to 0.0135 (0.000-0.025) at the end of the 8th week. Based on the non-parametric test analysis with the Man Whitney test in Table 3, the results obtained before treatment have p=0.114, and after administration of VCO, the p-value is 0.989 (p>0 .05).

The mean BMI value in the control group increased from 19.04 ± 3.05 kg/m^2 before intervention to 19.29 ± 3.33 kg/m^2 at the end of the 4th week and again to 20.12 ± 4.08 kg/m^2 at the end of the 8thweek. The mean BMI value in the treatment group increased from 17.53 ± 3.33 kg/m^2 before the intervention to 18.48 ± 3.56 kg/m^2 at 4th week and again to 19.32 ± 3.62 kg/m^2 at the end of the 8th week. From the results of the unpaired t-test on BMI status before treatment, the p-value was 0.614. Then, at the end of the 4th week, the BMI status had p=0.878, and at the end of the 8th week, the BMI status had p=0.43 (Table 3).

DISCUSSION

Several studies showed that VCO was beneficial against TB. In pulmonary TB patients who are administered first-line ATD in conjunction with VCO tablets, the conversion of AFB sputum can be expedited. The content of a long chain of saturated fat known as glyceryl monolaurate, which functions as a potent bactericide for pulmonary tuberculosis, accelerates the conversion (Djannah, 2022).

Sample characteristic

In 2020, based on WHO data, it is estimated that 5.6 million men (56%) and 3.3 million women (33%) will be infected with MTb germs. Based on data from the Ministry of Health regarding the total number of tuberculosis cases, tuberculosis cases in men more than in women both in 2021 (men 57.7%; women 42.3%) and 2022 (men 57.8%; women 42.2%) (Sukarli, 2022). This aligns with this research where the majority were men in the placebo group, as many as 12 patients (60%), and 14 patients (70%) in the treatment group.

Age is a unit of time in a person's life from birth to the present. The age classified as unproductive is 58 years, while the productive is 15–58 years. The productive age refers to the period in a person's life when they are most likely to interact frequently with others in educational, professional, or other social settings (Novita, et al., 2022). TB sufferers in productive age reached 75%, while the rest occurred in non-productive age (Novita, et al., 2022). The data presented aligns with the findings of this study, indicating that the majority of individuals in the research sample were between the ages of 45 and 54 and >55 years old, accounting for 30% each in the treatment group. Similarly, in the control group, individuals aged 35-44 and >55 years old accounted for 30% each.

Cigarettes contain 4500 harmful substances that enter the body and damage some of the lung's defense mechanisms, which can interfere with mucosal cleansing and decrease the function of alveolar macrophages to phagocytose bacteria (Velayati & Farnia, 2016). The research revealed that 26 individuals (65%) from the 40 research samples smoked. The treatment group consisted of 14 patients, while the control group consisted of 12 patients. Therefore, it was hypothesized that the immune system declined since many of the research subjects smoked, resulting in the discussion of the healing process from pulmonary TB.

In this study, the majority (58.3%) had a Brinkman index of 200-599, indicating that there were moderate smokers, and there were 17.1% of heavy smokers with a Brinkman index of more than 600 in the control group. Meanwhile, in the treatment group, the Brinkman index was lower, with 50% moderate smokers and 7.1% heavy smokers. The toxins caused by smoking accumulate in the body over time, causing more dangerous consequences (Maqfirah, et al., 2020).

Comorbidities associated with the development of tuberculosis and poor outcomes are HIV infection, diabetes mellitus (DM), kidney disease, and smoking, as described in Figure 2. Diabetes, smoking, and HIV infection are known to influence the metabolic state of the host, macrophages, and systemic levels (Llibre, et al., 2021). In this study, there was one sample (2.5%) who had comorbid HIV in the control group, and nine samples had comorbid DM (22.5%). In TB patients, the prevalence of DM after screening ranges from 1.9% to 35%, with the highest rates in countries with high diabetes rates (Fadillah, et al., 2021).

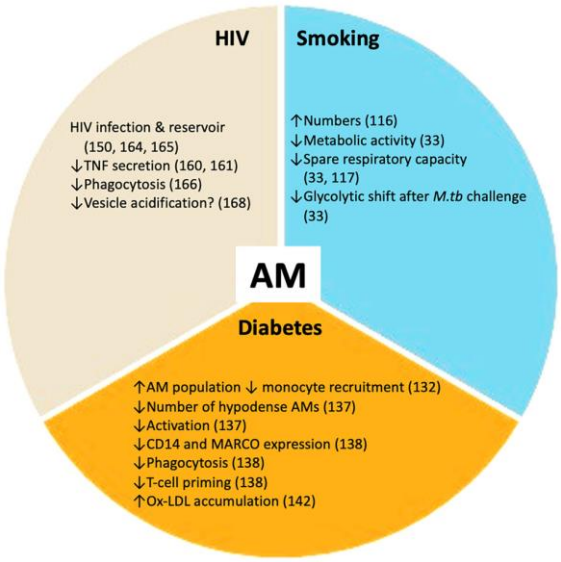

Figure 2. Comorbid in tuberculosis affect on alveolar macrofag. smoking, HIV infection, and diabetes disturbed alveolar macrophage phenotype (Bahtiar, 2021).

Relationship between VCO and AFB sputum conversion improvement

At the end of the 4th week, the Chi-Square test tabulation results indicated no relationship between VCO administration and AFB sputum conversion, as indicated by p=0.110 (p>0.05). Similarly, the Chi-square test results on AFB sputum conversion at the end of the 8th week revealed that two cells had an expected count of <5, necessitating a Fisher exact test. The results were p=0.231 (p>0.05), indicating no relationship between VCO administration and, at the end of the 8th week, an increase in the rate of AFB sputum conversion. There was no significant increase in AFB sputum conversion in the 4th and 8th weeks after VCO administration. This might have been because of factors that made the results unclear, such as smoking, the level of bacteria in AFB sputum, and having DM simultaneously. In numerous studies, smoking is an independent predictor of changes in sputum conversion. Smoking suppresses the lung's defense mechanisms against infection (Anandaraj, et al., 2017).

Administering VCO has a positive effect on increasing the conversion of AFB sputum. Sputum conversion is a strong predictor of the effectiveness of TB treatment. AFB sputum conversion was 60–80% in the first month and 95% in the second month (Dewi, 2019). In this study, the conversion results

in the first month for controls who received a placebo were 45% lower than in previous studies. Compared to previous studies (Djannah, 2022), those who received VCO converted 70% less AFB sputum. Meanwhile, in the second month of the study, the control conversion rate was 85%, which was lower than the previous study (Djannah, 2022), and those who received VCO resulted in 100%, which was higher than the earlier research findings.

At the end of the fourth week, 45% of the AFB sputum conversion failure rate was still positive for 1, and 5% was positive for 2 cases. Then, at the end of the eighth week, 15% of those who failed to convert were three patients. This indicated that these three individuals' bacterial count remains elevated, and this patient had comorbid DM. This was based on the hypothesis that the immune system's impairment in patients with TB and DM leads to a decrease in the activation of alveolar macrophages and the ability to produce interleukins, resulting in a delayed conversion of AFB sputum (Anandaraj, et al., 2017). In this study, the comorbid condition of DM was controlled with regular treatment.

The relationship between VCO and reducing SOD levels

Chattopadhyay's, (2019) study measured serum SOD activity in pulmonary TB patients treated with first-line ATD for 0–15 days and then one month after the next ATD. Pulmonary and extrapulmonary TB patients had significantly increased SOD levels before treatment, which can be used as an early marker of MTb infection. Serum SOD was reduced by 31% in pulmonary TB patients and by 29% in extrapulmonary TB patients after one month of first-line ATD. In some patients, SOD levels may remain elevated during the first month of treatment due to drug resistance. Consequently, some patients must respond to first-line ATD (Chattopadhyay, 2019).

The results of the Man-Whitney test in this study were $p>0.05$, indicating that there was no statistically significant difference in the administration of VCO to reduce SOD levels in pulmonary TB patients. The absence of statistical significance may be attributed to the presence of factors that affect oxidative stress in pulmonary TB patients, such as hypertension, diabetes mellitus, and smoking behaviors (Cardoso, et al., 2015).

At the end of the eighth week, the treatment group experienced a proportional decrease in SOD levels compared to before the VCO treatment. This was due to a reduction in the oxidative stress process, considered a marker of recovery for pulmonary TB patients, and a decrease in the virulence of MTb germs. The pulmonary tuberculosis infection process resulted in elevated intracellular oxidative stress conditions, leading to higher SOD levels before treatment than after treatment.

The effect of VCO on nutritional status

The unpaired T-test analysis found $p>0.05$, so there was no relationship between VCO administration and increasing BMI levels in the control and treatment groups before the intervention at the end of the 4th and 8th weeks. This was due to the non-homogenized nutritional status in the study, indicating that not only the micronutrient content of VCO but also multifactorial factors such as nutritional intake could improve nutritional status (Cendhikalistya & Makiyah, 2009; Iswati & Nuraini, 2023).

In this study, there was a proportional increase in nutritional status in the treatment group, from poor dietary status to good nutrition after VCO administration. Poor nutritional status raises the risk of developing pulmonary TB. After the intervention in the 4th week, the situation remained unchanged, with 50% of the sample experiencing malnutrition, which improved to only 45%. Meanwhile, 60% of the sample in the treatment group was malnourished. After the fourth week, it rose to 50% of those underweight. In the 8th week, it was found that 30% were still malnourished. As a result, the effect of VCO on nutritional status tends to increase compared to controls.

Strength and limitations

The study's strength lies in the proportional increase in AFB sputum conversion speed between the treatment and control groups at the end of the 4th and 8th weeks. In proportion, the treatment group's mean BMI increased from malnutrition to adequate nutrition at the end of the 4th and final week of the 8th, compared to the control group. At the end of week 8, there was a more significant reduction in SOD levels in the treatment group than in the control group, according to the median value.

The study's limitation was that statistical tests were not performed for confounding variables. So, it was not straightforward to see whether confounding variables in this study could have influenced the results. In this study, the antioxidant level was only SOD. In contrast, other endogenous antioxidants,

such as glutathione peroxidase and catalase, were not used, but they also have a role in fighting oxidative stress. Apart from that, this study did not use radiological images related to bacteriology. The lack of homogenization for comorbid conditions could be a weakness. Homogenization of nutritional status classification is still needed.

CONCLUSION

At the end of the 4th and 8th weeks, the treatment group increased the speed of AFB sputum conversion compared to the control group. There was also a shift in the mean BMI from malnutrition to good nutrition in the treatment group compared to the control group at the end of the 4th and final weeks. In the final week, there was a more significant reduction in SOD levels in the treatment group than in the control group, according to the median value.

When compared to the control group, there was no difference in the rate of AFB sputum conversion, SOD levels, or BMI values in pulmonary TB patients who were given virgin coconut oil.

Further research is needed to examine the influence of nutritional intake, smoking habits, gender, and comorbidities on AFB sputum conversion after VCO administration. It is also necessary to assess the severity of lung parenchymal damage, which can affect AFB sputum conversion. A more extensive research population is required for future research. It is best to homogenize comorbid conditions and nutritional status for future research.

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Conflict of Interest
The authors declared there is no conflict of interest.

Ethic Consideration
Ethics permission was obtained with the approval and consideration of the Ethics Commission of the Faculty of Medicine, Lambung Mangkurat University (No. 314/KEPK-FK ULM/EC/X/2023) on 02-10-2023, and the Ethics Commission of the Research and Development Agency of ULIN Hospital Banjarmasin (No. 162/VII-Reg Riset/RSUDU/23) on 25-07-2023.

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Author Contribution
MAN contributes to the conception and design, analysis and interpretation of the data, drafting of the article, and critical revision of the article for important intellectual content and final approval of the article. MI contributes to the conception and design, collection and assembly of the data, drafting of the article and final approval of the article. J contributes to the analysis and interpretation of the data, drafting of the article, and final approval of the article. H contributes to the analysis and interpretation of the data and final approval of the article. IA contributes to the analysis and interpretation of the data and final approval of the article. EK contributes to the critical revision of the article for important intellectual content and final approval of the article.

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