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Nutritional Values and Health Protective Properties Of Coconut Oil

***Jansen Silalahi*[1.2]**
[1]*Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Universitas Sumatera Utara, Medan Indonesia*
[2]*Nanomedicine Center, Universitas Sumatera Utara, Medan Indonesia*

Abstract. Chemically, fat or oil is a mixture of triacylglycerol molecules, in which glycerol esterified with three fatty acids. Fatty acid is a monocarboxilic acid containing even number of carbon atom started from 4 to 22. Based on the length of fatty acid in triacylglycerol, fats and oils can be classified into two groups; medium chain triglycerides and long chain triglycerides. Coconut oil belongs to medium chain triglycerides oil because it's fatty acids consist mostly of medium chain fatty acids (C4:0 to C12:0) and dominated by lauric acid (C12:0), hence usually called as lauric oil. In the year of 1950s, coconut oil was claimed that saturated fats, including coconut oil, could increase blood total cholesterol and hence is atherogenic, while unsaturated fats decrease total cholesterol. However, in 1990s, coconut oil was found to be different from the other saturated oils. Coconut oil composed of medium chain fatty acids with high amount of lauric acid. Coconut oil is metabolized differently from long chain triglycerides saturated oil, and therefore coconut oil has numerous beneficial nutritional values and health promotion. Consumption of food rich in medium *chain* fatty acids reduces the level of body fat and the decrease the risk of heart disease, diabetes, increase mother's milk quality and active as potential antibacterial agent.

Keywords: Coconut oil, triglycerides, lauric acid, nutritional value, health protective

Abstrak. *Secara kimiawi, lemak atau minyak merupakan campuran molekul triasilgliserol, di mana gliserol diesterifikasi dengan tiga asam lemak. Asam lemak adalah asam monokarboksilat yang mengandung atom karbon bilangan genap mulai dari 4 sampai 22. Berdasarkan panjang asam lemak dalam triasilgliserol, lemak dan minyak dapat diklasifikasikan menjadi dua kelompok; trigliserida rantai sedang dan trigliserida rantai panjang. Minyak kelapa termasuk dalam minyak trigliserida rantai menengah karena asam lemaknya sebagian besar terdiri dari asam lemak rantai menengah (C4: 0 sampai C12: 0) dan didominasi oleh asam laurat (C12: 0), oleh karena itu biasanya disebut minyak laurat. Pada tahun 1950-an, minyak kelapa diklaim sebagai lemak jenuh, termasuk minyak kelapa, dapat meningkatkan kolesterol total darah sehingga bersifat aterogenik, sedangkan lemak tak jenuh menurunkan kolesterol total. Akan tetapi, pada tahun 1990-an, minyak kelapa ditemukan berbeda dengan minyak jenuh lainnya. Minyak kelapa terdiri dari asam lemak rantai sedang dengan jumlah asam laurat yang tinggi. Minyak kelapa dimetabolisme secara berbeda dari minyak jenuh trigliserida rantai panjang, dan oleh karena itu minyak kelapa memiliki banyak nilai gizi yang bermanfaat dan meningkatkan kesehatan. Konsumsi makanan kaya asam lemak rantai sedang menurunkan kadar lemak tubuh dan menurunkan resiko penyakit jantung, diabetes, meningkatkan kualitas ASI dan aktif sebagai agen antibakteri potensial.*

*Corresponding author at: Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

E-mail address: jansen@usu.ac.id

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1. Introduction

Due to the high content of saturated fatty acids (±90%), coconut oil is commonly regarded as harmful to health. However, based on many clinical studies clearly indicate its positive effect to maintain living functions and health promotion, both children and adults [1,2].Coconut oil and palm kernel oil (PKO) composed of medium chain fatty acids (MCFA) dominated by lauric acid and they are called lauric oils. [3].Two kinds of coconut oils that can be obtained from meat of coconut tree (*Cocosnucifera*), they are coconut oil (copra oil) and virgin coconut oil (VCO). Coconut oil is extracted from copra by heating process, while VCO is prepared from milk of fresh and mature coconut meat of coconut fruit and processed at low temperature. Coconut oil and VCO are different from most of the other common oils. Coconut oil is composed of short chain fatty acid (SCFA) and MCFA (C6:0 – C12:0), and therefore classified as medium chain triglyceride (MCT). Other oils are usually composed of long chain fatty acids (LCFA) and hence long chain triglycrides (LCT). Due to the unique properties of coconut oil, it has been used in health promotion and also in ailments prevention and medication [1,4,5]. The quality of VCO is determined by MCFA content, especially lauric acid which is influenced by variety and oil extraction process. VCO also contains bioactive and antioxidants components [6].

In the human body, triglycerides of VCO are hydrolyzed into monoglycerides and free fatty acids, which have antibacterial, antifungal, antiviral, hypoglycemic activities, prevent obesity, induce insulin sensitivity and hence decrease the incidence or prevent diabetes. VCO increases absorption of magnesium and calcium compared to LCT [4,7,8]. Nutritional values and health protective properties of coconut oil will be discussed.

2. Coconut Oil

Coconut oil is extracted by either hot or cold pressed techniques, and the method used influence the quality. Coconut oil is made from the dried coconut meat (copra) processed at high temperature. VCO extracted from fresh mature coconut meat at low controlled temperature or cold methods is found to retain the highest levels of bioactive components such as tocotrienols, squalene, tocopherols and phytosterols. Fatty acid composition of VCO, and refined coconut oil is not significantly different [7, 9]. Coconut oils are unique group of oil products, characterized by the high content of saturated fatty acids (±90%), especially the lauric acid (C12: 0) with the level of about 50% and called lauric oils. Besides lauric acid, coconut oil contains about 17.19% for myristic acid (C14:0), 8.80% for palmitic acid (C16:0), 6.76% for caprylic acid and 6.37%

for capric acid. Other saturated fatty acids are in the range of 0.50 (caproic acid (C6:0), 3.03% (stearic acid (C18:0).The unsaturated acids are relatively low in coconut oil. Oleic acid (C18:1) and linoleic acid (C18:2) are the highest fatty acids incoconut oil, with a content of 5.25-10.54% for oleic acid and 0.79-2.58% for linoleic acid. Linolenic acid (C18:3) was found only 0.01%-1.10% [1,2,10].

Coconut oil is produced with process of refining, bleaching, and deodorizing, and altering the nature of the oil. This production method removes the nutritional value of various bioactive components such as phtytosterol, phenolics, which are normally lost during the manufacturing of coconut oil. This method of production makes coconut oil different from VCO containing vitamins, minerals, and antioxidants. [2,9].

3. Nutritional Values

VCO and palm kernel oil (PKO) are composed mainly of MCT while most of the other oils belong to LCT containing LCFAs. In the body, MCT and LCT are differently metabolized by different lipase enzymes active on Sn-1 and Sn-3 positions in fat or triacylglycerol TAG molecules. MCT is hydrolyzed in mouth by lingual lipase and gastric lipase in stomach. The hydrolyzed products of MCT are 2-monoacylglycerol (2-MAG) and MCFA which are rapidly absorbed by the enterocytes into the portal vein and then directly enter the liver to be quickly metabolized into energy, hence MCT does not increase blood triglyceride (TG). On the other hand, LCT is not digested in the mouth and stomach. LCT in the small intestine should first be emulsified by bile acid and then hydrolyzed by pancreatic lipase into 2-monoglycrides and free LCFA, absorbed by the enterocytes and converted back into new triglycerides. The new triglycerides enter the lymph system as chylomicrons then transported to the heart and circulation, hence, LCT increases blood triglyceride. Because of its rapid metabolism, MCT oils are beneficial to prevent and treat obesity. MCT oil's unique physicochemical properties are also known to be beneficial for improving health condition in general and lipid profile in particular [11,12,13,14,15]. The other difference between MCTs and LCTs is the energy yield obtained in the oxidation process, for short chain fatty acids is 8.3 kcal/g while for long chain fatty acids is 9.2 kcal/g. MCT oil was found to be useful for nutritional management of patients with impaired fat digestion. [2,10,].

Fatty acid composition of coconut oil is similar to that of VCO, but VCO also contains many biologically active compounds such as sterols (70 mg/100 g), tocols (4 mg/100 g) and phenolic compounds (50 mg/100 g). [2]. These bioactive components makes VCO to have additional beneficial values compared to coconut oil. The fatty acids composition of VCO is dominated by medium chain fatty acids (more than 90% of the sum of all fatty acids), which provide beneficial effects on the human body. A number of clinical studies clearly show its beneficial

effects on the skin, heart, liver and brain of humans. Coconut oil supplementation is also important to prevent and treat cancer, and also reduces the biological activity of many pathogenic bacteria and viruses. [2,10,]. Therefore, VCO provides health benefits and diseases prevention by several mechanisms including cardioprotective, antidiabetic, and antithrombotic effects etc. [10,16].

Monolaurin has Generally Recognized as Safe (GRAS) status and is considered to be nontoxic. It is effective against many microorganisms and can be taken as a daily basis, given that evidence suggests it does not create antiviral or antibacterial resistance. Both monolaurin and coconut oil are exellent choices for both therapeutically and preventively.[17]. Therefore, coconut oil has been now classified as a functional food; food that provides health benefits over and above the basic nutrients. [18]. There are over 100 patents have been filed world-wide on the use of monolaurin in a diverse range of applications as food and non-food applications, such as medical procedures, disinfection and sanitizing agents, antimicrobial polymer compositions, animal feed supplements, and others. [10]

VCO is natural, not chemically refined and considered safe for human consumption, thus VCO can also be considered as a functional food supplement. VCO has shown greater beneficial effects than copra oil in lowering lipid levels in serum and tissues and in reducing LDL oxidation by physiological oxidants attributed to the biologically active polyphenol components present in the oil [2,7].

4. Health Protective Properties

4.1 Cardioprotective

In 1953-1957, based on his investigations, Ancel Keys claimed that saturated fats are atherogenic including coconut oil, by increasing total cholesterol (TC), while unsaturated fats decrease TC. In 1960s, unsaturated fat industries in United States took advantage of these statements to promote their products mainly soybean oil. Not until 1990s, negative perspective on coconut oil was cleared because formerly it had not been known that coconut oil is different from other saturated fats [1,10,19,20]. Coconut oil contains high amount of MCFA, which has numerous health benefits, as mentioned above. Consumption of food rich in MCFA reduces the level of body fat and heart disease risk. [7,9].

It has been found that coconut oil contains lauric acid preventing various cardiovascular diseases risks such as high blood pressure or atherosclerosis. Coconut oil does not increase bad cholesterol LDL level, but increase good cholesterol high density lipoprotein (HDL) level and hence decrease LDL: HDL ratio. Whereas soybean oil diet decrease TC and LDL fraction but also HDL decreased and increase LDL: HDL ratio. Consuming coconut oil decrease body mass

index (BMI) and waist circumference [2]. While small amounts of lauric acid may be found in chylomicrons as triglycerides, it is not found in phospholipids. Consistent with these properties, coconut oil has not been shown to contribute to cardiovascular disease and atherosclerosis[10].

Lauric acid disappeared more rapidly than palmitic acid from the blood, and was also oxidized more rapidly. This suggests that, while some of the ingested lauric acid enters the blood stream, it is rapidly metabolized and only a small amount is stored in the liver as triglycerides. [9,21]. Lauric acid has been shown to diffuse freely across the mitochondrial membrane, while longer chain fatty acids require carnitine. Thus, lauric acid can be rapidly transported into the mitochondria via physical diffusion or with assistance of carnitine. Lauric acid is rapidly metabolized in the liver by β-oxidation producing acetyl-CoA for the citric acid cycle. In liver mitochondria, acetyl-CoA can also be converted to ketone bodies, acetoacetic acid, beta-hydroxybutyric acid and acetone. Although the liver synthesizes ketone bodies, it has little β-ketoacyl-CoA transferase and therefore is not able to utilize ketone bodies. The ketone bodies are transported to other tissues such as the brain, muscle and heart which have the enzymes to convert ketone bodies to acetyl-CoA to provide energy. [7,10].

Among all fatty acids, lauric acid contributes the least to fat accumulation consistent with the observations that coconut oil is a non-fattening source of energy. MCFAs show different metabolic and physiologic properties to LCFA (≥C14), so that, the chain length should be specified when using the term “saturated fatty acid”. [10]. Recently, a study conducted by Margata et al [21] has found that VCO and partially hydrolyzed VCO more significantly than VCO without hydrolysis to decrease serum total cholesterol, LDL, TG levels, TC/HDL, LDL/HDL ratio, and liver enzyme (SGOT and SGPT) while increase HDL in dyslipidemic rats.

Coconut oil’s regular use in diet would regularize blood fat and is known to increase the HDL cholesterol fraction while decreasing the LDL and triglycerides significantly. This is to disprove the myth that coconut oil increases cholesterol and triglycerides. [18,22]. VCO contains a high total phenolic content (11.82–29.18 mg gallic acid equivalents [GAE]/100 g oil), which is responsible for its high antioxidant properties. The high polyphenolic content of VCO is responsible for its antioxidant effects preventing the progression of atherosclerosis. VCO has also been found to enhance antithrombotic effects related to inhibition of platelet coagulation and promote anti-inflammatory effects.[2,9].

4.2 Antidiabetic Activity

Diabetes mellitus (DM) is a metabolic syndrome characterized by high level of blood sugar above normal due to the dysfunction of blood glucose regulation related to insulin deficiency secreted from pancreas and insulin inactivity due to the obesity. There are two types of DM i.e; Type 1 is insulin diabetes dependent diabetes mellitus (IDDM), and Type 2 that is non-insulin

dependent diabetes mellitus (NIDDM). DM may cause complication such cardiovascular disease, retinopathy, neuropathy and nephropathy, so that DM is considered as high risk disease because it can cause death. [8,23,24,25]

The healthy fat in VCO plays important role in regulating blood sugar. When VCO in combination with carbohydrates in a meal, the carbohydrates will be broken down more slowly into glucose so blood sugar levels remain stable after meal. MCFAs in VCO are more suitable for energy use rather than fat storage which is opposite to LCTs. [23,26], If a cell cannot get sufficient amount of glucose, the cell will be hungry and finally will die and epsecially glucose is vital as source of energy in the brain [7,25]. Lauric acid is rapidly transported across the mitochondrial membrane by passive diffusion without carnitine. Lauric acid is rapidly metabolized and oxidized in the liver into ketone bodies, which are important energy sources for extrahepatic organs in the body, such as the brain, heart and muscle. The presence of ketone bodies in the blood circulation increase insulin secretion and induce hypoglycemia. [10]. Among dietary fatty acids, lauric acid is the most highly oxidized and contributes the least to fat accumulation and reduce obesity and also speed up metabolism [2,10].

MCFA provide about10% less energy than LCFA. Although the difference is not significant, this is just one of the many advantages of MCFA, as it will reduce obesity to some degree, and obesity is an independent risk factor for hypertension, hyperlipidemia and diabetes.[7]. A study reported that another lauric oil PKO was active to decrease blood glucose level and hydrolysis of PKO increased hypoglycemic activity and found to be similar with antidiabetic metformin in rats. [8].MCT consumption improves cognition without adversely affecting adrenergic or symptomatic responses to hypoglycemia in intensively treated type 1 diabetic subjects. MCT offers the therapeutic advantage of preserving brain function under hypoglycemic conditions without causing deleterious hyperglycemia [23,27].

4.3 Hepatoprotective

The liver is considered to be the most important organ of the human body. It is responsible for control storage as well as carbohydrate metabolism, protein synthesis, and detoxification. A study reported that the use of the coconut oil supplement reduces liver damage in animals, and also suggest the need of research to achieve similar results in the human body. It is also found that coconut oil has positive effect on the body detoxification. [2]. Changes in enzyme activity is an early marker for the tissue damage by toxic substances or disease conditions. SGOT and SGPT are liver enzymes that occur during hepatic cells damage [28]. VCO is shown that rats fed with VCO and hydrolyzed VCO significantly decrease SGOT and SGPT levels in dyslipidemic rats. This suggests that VCO and HVCO are not toxic to the liver.[21]..

4.4 Ketogenic Diet

Epilepsy is a neurological disorder consisting of recurrent spontaneous seizures, caused by an imbalance between cerebral excitability and inhibition. This imbalance is implicated for a tendency towards uncontrolled excitability.[29]. Alzheimer's disease (AD) is developing gradually with various types of neurodegenerative disorder, which causes chronic disease in the late adult life. AD is a complex disease that develops over many years, such as diabetes, heart disease and other chronic conditions [7,30].

The use of glucose for energy is vital in the brain, but this system is impaired in AD partly due to disruption of the insulin signalling mechanism. [7].The blood–brain barrier (BBB) is a brain endothelial structure to protect the brain from foreign substances, so that more than 98% of all small-molecule drugs can not cross the BBB. Fatty acids cannot pass BBB; thus, the human brain primarily depends on glucose. It was observed that starvation-produced ketone bodies (ketosis) could have an impact on brain disorders.[29]. Fats can be used as a non-carbohydrate fuel source by the formation ketone bodies; acetoacetate (AcAc), 3-ß-hydroxybutyrate (3HB) and acetone. Ketones bodies are used for energy production, whereas acetone is a breakdown product of AcAcA and 3HB can cross cell membranes freely, and cross the BBB through proton-linked, monocarboxylic acid transporters. Ketone bodies are absorbed by cells and converted back to acetyl-CoA, which enters the Krebs cycle and is oxidized in the mitochondria to provide ATP and also precursors of acetylcholine in neurons. Alternatively, ketone bodies can be converted to acetyl-CoA in the brain to be synthesized into polyunsaturated LCFA. Ketone bodies are used as an energy source during glucose deficiency [7,31].

Diet that consists of very low carbohydrates levels and high fat levels have capacity to produce high levels of ketone bodies (3HB; AcAc and acetone) known as traditional or classic ketogenic diet (KD) developed in 1921, which is based on LCT. [32]. A KD has been found to be one of the most effective therapies for drug-resistant epilepsy and severe myoclonic epilepsy in infancy. Despite being used for many decades, the mechanism whereby a KD can reduce epilepsy is not fully understood. Recent research has suggested ketosis, reduced glucose, elevated fatty acid levels and enhanced bioenergetics reserves, as well as neuron-specific effects such as modulation of ATP-sensitive potassium channels, enhanced neurotransmission, increased brain-derived neurotrophic factor expression due to glycolytic restriction and reduced neuroinflammation may be involved. [7,32].

KD is a high-fat, low-carbohydrate, adequate protein diet that has been used as a treatment for epilepsy for about 90 years. This therapy was originally designed to mimic the biochemical changes associated with fasting, a treatment to control seizure activity.[31]. KD contains a 4:1 or 3:1 ratio (by weight) of fat to combined protein and carbohydrates. The fats used in KD are

mostly LCT which may increase the risk of atherosclerosis a condition known to increase the risk of AD. Later studies have shown that this side effect can be overcome by using MCT such as coconut oil in KD that is rich in MCFA, and known as the MCT-KD, more nutritionally adequate than KD. MCT-KD is still effective in treating epilepsy disorders yet reduce cardiac risk. KD rich in MCFA has significant effects on lowering the ratio of cholesterol: HDL compared with the classic KD [7,].

Classic KD which is based on LCFA, leads to a higher risk of atherosclerosis, a condition known to increase the risk of AD [7]. The MCT-KD contains less fat overall, as it includes MCFA (from coconut oil) that can provide a greater amount of ketone bodies per gram of fat and thus allows more carbohydrate and protein in the diet, making the diet more palatable than the classic KD. [7,32]. To day, there are three ketogenic diet; traditional KD, MCT-KD and a combination of the traditional and MCT diets. [29,32].

Recently, there has been interest in the potential of the ketogenic diet in the treatment of neurological disorders other than epilepsy, including AD and Parkinson's disease. MCT-KD may not only provide symptomatic benefit, but could have beneficial disease modifying activity applicable to a broad range of brain disorders characterized by the death of neurons. Ketogenic diet might have greater efficacy in children than in adults, as younger brains have greater capacity to transport and utilize ketone bodies as an energy source [7,32].

4.5 Antimicrobial Activity

Complete hydrolysis of TAG will be converted into one glycerol and three free fatty acids. Fatty acids were found to be potential antibacterial agents. Antibacterial activity of free fatty acid or its monoglyceride has been tested separately [33,34]. Antimicrobial activity is due to free fatty acids of medium chain and their monoglycerides. Triglyceride and diglyceride are not effective as antibacterial. Of the free fatty acids present in coconut oil, lauric acid (C:12:0) is proven to be the most active as antibacterial agent compared to caprylic acid (C8:0), capric acid (C10:0), and myristic acid (C14:0). Free fatty acids and their monoglycerides inactivate bacteria by disrupting plasma membrane of lipid bilayer [17,20,34.].

Antibacterial activity of hydrolyzed oil is affected by length of chain and unsaturation of fatty acid present in the fat molecule. Hydrolyzed VCO which is composed of saturated medium chain fatty acid especially lauric acid has the highest antibacterial activity, followed by hydrolyzed soybean oil composed of unsaturated long chain fatty acid and the lowest is by hydrolyzed palm oil composed of saturated long chain fatty acid. Saturated fatty acids longer than 14 have no antibacterail activity. [35,36].

Hydrolyzed oil is found to be active as antibacterial against Salmonella typhi and Lactobacillus plantarum, but antibacterial activity of hydrolyzed oil is more effective against Salmonella typhi than Lactobacillus plantarum. [35]. Enzymatic partially hydrolysis of the VCO can inhibit the growth of Salmonella in *in-vitro* and *in–vivo* studies.[37].VCO was also found to modulate TCD4+ and TCD8+ Cell Profile of Doxorubicin-Induced Immune-Suppressed Rats[8].

4.6 Coconut Oil for Children's Health

VCO is safe for consumption by pregnant and lactating women. Consumption of VCO or coconuts products (such as milk, shredded coconut and coconut oil) by pregnant women and lactating women have a positive effect for the baby. [38,39]. Breast milk contains much MCFA, which can help the absorption of nutrients, digestive function, regulate blood sugar levels and protect the baby from microorganisms bullies [23,40]. VCO consumption by breast feeding mothers found to be beneficial on the growth of baby, and the lauric acid content of breast milk increase significantly. [38]. Monolaurin and free fatty acids showed no adverse effects on the normal microbial flora in the digestive tracts but much more potent against bacterial pathogens. [41].

Lauric acid gets converted in human system into monolaurin, the best that mother's milk has. Other than mother's milk, monolaurins are found only in coconut oil. New born babies and infants depend on the monolaurins for their immune system development and their capacity to withstand any infection. The best alternative food fat for the infant when mother's milk is not available is coconut oil (in baby foods). [18]. Coconut oil has been found to be an excellent moisturizer for dry skin conditions and is known to be even absorbed from the skin surface of preterm babies. Coconut oil penetrates hair roots to keep hair healthy and clean. [18].

Both animal and human can metabolize some monolaurin from lauric acid. Mother's milk, a rich source of lauric acid, may also provide a lipase that converts the triglycerides to monoglycerides by the infant [7,39]. Even small amounts of monolaurin converted from lauric acid from coconut oil or mother's milk and lauric acid are still virucidal and bactericidal. Monolaurin was also shown to be effective in blocking or delaying the production of exotoxins by pathogenic gram-positive bacteria. [10].Human milk provides approximately 3.5 percent of calories as lauric acid for infantand has has been noted to have up to 12 percent of the total fat as lauric acid (6.6 percent of calories). [7].

5. Conclusions

Coconut oil is consumed in tropical countries for a long period of time. Native diets high in coconut oil consumption show that this population is generally in good health. Although saturated oil including coconut oil was ever claimed to be atherosclerotic, but since 1990s,

many studies have proven that coconut oil is different from the other oils. The oil contains 90% of saturated fatty acids consisting of MCFAs in the form of triglycerides, and about 8% of unsaturated fatty acids consisting of oleic and linoleic acids as triglycerides. In human body coconut oil and VCO are hydrolyzed in to monoglycerides and free fatty acids which are absorbed and transported quickly in to the liver and then oxidized into energy. Through this digestion, coconut oil is known to have good nutritional value and health protective properties. VCO and coconut oil decrease CVD risk by increasing HDL and decreasing LDL/HDL ratio. Ketogenic diet based on MCFA can be used in neurodegenerative disease in children and later life adults. VCO is a nature mimic of the human breast milk fat as it contains lauric acid at high level which is potential antibacterial and therefore recommended to be used in infant formulae. Further human studies are necessary to assure the positive physiological and pharmacological activities of coconut oil.

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