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REVIEW ARTICLE

Chemical and Biological Properties of Lauric Acid: A Review.

*S Sandhya, Joyeeta Talukdar and Debabrat Bhaishya Ph.d.

Department of Bioengineering and Technology, Gauhati University Institute of Science and Technology (GUIST),
Guwahati- 781 014, Assam, India.

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*Corresponding Author

S Sandhya.

Abstract

Health, growth, immunity and development of infants depend on their breast milk consumption. Lauric acid is one important constituent among the various nutritional factors that complex together to form the breast milk. This medium chain triglyceride with 12-carbon atom chain component has many medicinal values. Lauric acid has been found to have present in 6.2% of human breast milk, 3.1% of goat milk and 2.9% in cow milk. Besides being present in milk its presence has been recognized in plant sources (mainly oil)-coconut, cohune and palm kernel oil in common. Coconut oil extracted from a single one contains approximately 50% of Lauric acid. The isolation of Lauric acid from plant sources hence is easier and convenient than animal sources with increase in the percentage of component extracted. Researchers conducted study on Lauric acid suggested, it to be a non-toxic, safe to handle component with long shelf-life. It is even easily absorbable and digestible by the body. This component has many therapeutic properties in human's health as such – prevention from various skin diseases, decrease in the bad cholesterol level, body weight deduction. Even antioxidant, antibacterial, antifungal, antiviral and anticancer capabilities are present in this Lauric acid. But, till date the evidence is currently ambiguous as to whether Lauric acid supplementation has a significant effect on body. This article gives a review on the beneficial properties of Lauric acid with details of natural sources to isolate this specific component. Even the probable biological applications of it are given in this review which may ponder a path to future drug development process in various aspects.

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Introduction:-

Lauric acid (LA) (Fig. 1) - a medium-chain triglyceride (MCT) is widely acknowledged as a "healthier" saturated fat. MCT molecules can be rapidly absorbed by body because of their ability to hydrolyze completely into fatty acids and glycerol by pancreatic lipase. Hence being an MCT itself lauric acid's specific chemical structure also allows body to absorb them as whole which makes them more easily digestible¹. Even when pancreatic juice secretion is reduced due to diseases, medium chain fatty acids have the ability to get easily digested and absorbed². LA is also used as source of direct energy because body processes them as carbohydrates¹. Found in abundance from natural resources it is inexpensive, has a long shelf-life is non-toxic and safe to handle. Like other fatty acids, LA is also said to increase total serum cholesterol but it is mainly attributed to increase the "good" blood cholesterol i.e. high-density lipoprotein (HDL) which helps to decrease atherosclerotic risk in the body^{3,4}. This is because medium chain fatty acids are not readily re-synthesized to triacylglycerol like long chain fatty acids. Instead these MCT are mostly bound with albumin as free fatty acids, transferred into portal blood, and transported to the liver, where they are transported to mitochondria and rapidly degraded through oxidation². Although the net effects of LA, to decrease the risk of coronary artery disease till date remains uncertain³. The saturated fatty acid, LA consist of 12-carbon atom chain, also known as *n*- Dodecanoic acid, Dodecyllic acid, Dodecoic acid, Laurostearic acid, Vulvic acid, 1-

Undecanecarboxylic acid and Duodecylic acid. Fig. 1 shows the chemical structure of LA. It is a white, powdery solid with a faint odor of bay oil that is insoluble in water⁵. If a type of carboxylic acid donates hydrogen ions and a base is present to accept them it forms neutralization between acid and base that produces water plus a salt as by-products. This neutralization process is mainly used for the production of soaps and cosmetics. LA when neutralized with sodium hydroxide produces sodium laurate, which is soap⁶. It is also used for molar mass identification of unknown substances via the freezing-point depression method where LA mixes with unknown substance by melting and cooling process. And then the molar mass of the unknown substances may be determined by recording the temperature at which the mixture freezes. Lauric acid is thought to be convenient because its melting point when pure is relatively high (43.8 °C)⁷.



Figure 1:- Chemical Structure of Lauric acid

Among the plant sources, many vegetables fats contain LA, particularly in coconut and palm kernel oils. The amount of LA found in foods is safe for health but there isn't enough information whether it can be used as medicine. Among animal resources LA is found in human breast milk, cow's milk and goat's milk⁵ too. But the mechanism of extraction from plant resources is much efficient than that from animal resources. The mechanism by which LA is consumed by the body is - more amount of it gets converted into monolaurin (glyceryl laurate). Finally, this monolaurin gets converted into HDA (2-Hexadecynoic acid) version of cholesterol and prevent body from bacterial infection. Monolaurin is commonly used in deodorants⁸. Fig.2 depicts the chemical structure of monolaurin. This review of LA, studied by us is the very first of its kind besides it has depicting the numerous essential medicinal values. This paper also aims to bring researchers time and attention on chemical and biological properties along with identification of natural sources to isolate and applications of lauric acid for future drug development process.

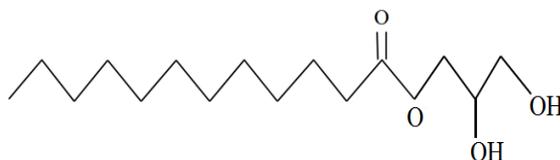


Figure 2:- Chemical Structure of Monolaurin

Chemical Properties of lauric acid:-

Being a component of triglyceride, LA is the type of MCT component found in human breast milk and helps boosting metabolism of the body. At normal room temperature, a MCT component looks colorless, transparent and low viscous "waterlike" liquid oil and odorless components². With unique chemical and biochemical properties this fatty acid is used for neutralization and molar mass identification of unknown substances via the freezing-point depression method. This dodecylic acid containing numerous medicinal values may cure many diseases with its unique ability of being easily absorbed and digested by the body¹. Table 1 represents the chemical properties of LA in tabular form. LA is an insoluble carboxylic acid that can donate hydrogen ions if a base is present to accept them. The reaction of LA with bases form neutralization, are accompanied by the evolution of substantial amounts of heat. This neutralization process is mainly used for the production of soaps and cosmetics. Lauric acid when neutralized with sodium hydroxide produces sodium laurate, which is soap⁷. In an aqueous solution, carboxylic acids may react with active metals to form gaseous hydrogen and a metal salt. This phenomenon also generate flammable or toxic gases along with heat by reacting with sulfites, nitrites, thiosulfates (to give H₂S and SO₃), dithionites (SO₂). They can even generate a harmless gas (carbon dioxide) but still heat when they react with carbonates and bicarbonates. Other chemical properties of carboxylic acids are they may initiate polymerization reactions and they often catalyze (increase the rate of) chemical reactions like other acids¹⁴.

Table 1:- Chemical properties of lauric acid

Sl. No.	Details of Chemical properties of Lauric Acid (LA)	
1.	Chemical name	Lauric Acid
2.	IUPAC name	Dodecanoic acid
3.	Other names	<i>n</i> -Dodecanoic acid, Dodecylic acid, Dodecoic acid, Laurostearic acid, Vulvic acid, 1-Undecanecarboxylic acid, Duodecylic acid
4.	Molecular formula	C ₁₂ H ₂₄ O ₂
5.	Molar mass	200.32 g mol ⁻¹
6.	Appearance	White powder
7.	Odor	Slight odor of bay oil
8.	Density	1.007 g/cm ³ (24 °C) ¹¹ , 0.8744 g/cm ³ (41.5 °C) ¹² , 0.8679 g/cm ³ (50 °C) ¹³
9.	Thermal conductivity	0.442 W/m·K (solid) ¹⁰ , 0.1921 W/m·K (72.5 °C), 0.1748 W/m·K (106 °C) ¹¹
10.	Refractive index(<i>n_D</i>)	1.423 (70 °C) ⁹ , 1.4183 (82 °C) ¹³
11.	Viscosity	6.88 cP (50 °C), 5.37 cP (60 °C) ¹²
12.	Melting point	43.8 °C (110.8 °F; 316.9 K) ¹³
13.	Boiling point	297.9 °C (568.2 °F; 571.0 K), 282.5 °C (540.5 °F; 555.6 K) at 512 mmHg ⁹ , 225.1 °C (437.2 °F; 498.2 K) at 100 mmHg ^{13, 14}
14.	Solubility in water	Insoluble
15.	Solubility	Soluble in alcohols, (C ₂ H ₅) ₂ O, phenyls, haloalkanes, acetates ¹⁵
16.	Solubility in methanol	12.7 g/100 g (0 °C), 120 g/100 g (20 °C), 2250 g/100 g (40 °C) ¹⁵
17.	Solubility in acetone	8.95 g/100 g (0 °C), 60.5 g/100 g (20 °C), 1590 g/100 g (40 °C) ¹⁵
18.	Solubility in ethyl acetate	9.4 g/100 g (0 °C), 52 g/100 g (20 °C), 1250 g/100 g (40 °C) ¹⁵
19.	Solubility in toluene	15.3 g/100 g (0 °C), 97 g/100 g (20 °C), 1410 g/100 g (40 °C) ¹⁵
20.	log P	4.6 ¹⁶
21.	Vapor pressure	0.42 kPa (150 °C) ¹³ , 2.13·10 ⁻⁶ kPa (25 °C) ¹⁵ , 6.67 kPa (210 °C) ¹⁷
22.	Acidity (p <i>K_a</i>)	5.3 (20 °C) ¹⁶
23.	Stability	Stable. Combustible. Incompatible with bases, oxidizing agents, reducing agents.

Biological properties of Lauric Acid:-

The LA may be used in the daily diet for appreciable amount to prevent many diseases. But the only way one could receive LA is from natural sources. Table 2 illustrates the list of natural sources with approximate percentage of lauric acid in them. Because of its easily absorbable and digestible properties by body a new breakthrough in research may be found that a natural LA is very safe to consume. LA is mostly found in plant material such as vegetables, coconut oil, cohune oil, palm kernel oil etc. They can be easy natural sources for isolating the acid in huge amount to study its biological activity for the development of new drug in future.

Now a day's medium chained fatty acid have attracted more attention as being part of a healthy diet, because they are absorbed directly into the portal vein, transported rapidly to the liver for β-oxidation, and thus increase diet-induced thermo genesis. By β-oxidation process LA is directly metabolized with successive removal of two carbon (acetyl) fragments from the carboxyl terminal end of the molecule¹⁶. This acid may also be metabolized by a route involving hydroxylation of its twelfth (ω) carbon atom by certain cytochrome P450 2C4A isoforms, followed by the oxidation of ω hydroxyl group to a carboxylic acid by cytosolic alcohol and aldehyde dehydrogenases^{17, 18, 19}. In the 1950s for the first time MCT was recommended as clinical dietary supplements of malnutrition syndromes, because of its rapid absorption and solubility. In the 1970s, started its utilization as edible oil and currently used as additive for foods, base material of pigments, and mold and lubricating oil in food production².

Table 2:- List of natural source of lauric acid

Identified Natural Sources	Quantity of LA found in respective natural source in percentage
In Animal source	
Human Breast Milk	6.2% of total fat
Cow's milk	2.9% of total fat
Goat's milk	3.1% of total fat
In Plant source	
Palm kernel oil	50%
Cohune oil	46.5%
Coconut oil	49%
Murumuru butter	47.5%
wild nutmeg	7.8–11.5%
Peach palm seed	10.4%
Betel nut	9%
Date palm seed	0.56–5.4%
Macadamia nut	0.072–1.1%
Plum	0.35–0.38%
Water melon seed	0.33%

Lauric acid (a major component of coconut oil and an important MCT fatty acid) possesses many types of therapeutic properties:-

Antibacterial activity:-

Laurostearic acid's use may prevent skin diseases because it has the ability to fight against various types of bacterial infections. As par example, from many decades people have been using coconut oil as a cure for fungal and bacterial infections on skin. This LA is one of the main ingredients of coconut oil (approx~50%) but study on use of pure LA directly to cure skin diseases is less evidenced. Recently Teruaki Nakatsujiet *al.*(2009) reported that LA shows the inhibitory effect on the growth of skin bacteria such as *Propionibacteriumacnes* isolated from the most common disorder of human skin i.e. acne vulgaris that affects up to 80% of individuals in their lives²⁰. Atopic Dermatitis (AD) is again a chronic skin disease where the skin turns dry and is readily infected and colonized by *Staphylococcus* species with an increased penetration of allergens. This is characterized by defects in the epidermal barrier function and cutaneous inflammation. In this phenomenon there is an increased transepidermal water loss where the ability of the stratum corneum to hold water is impaired thus causing decreased skin capacitance and hydration^{21,22,23}. However, researches have reported that Virgin Coconut Oil [(VCO) containing ~50% of LA] shows effect on AD compared to mineral oil and virgin olive oils^{21,22}. Thus, the excellent antimicrobial properties of LA may increase the demand of it in the pharmaceutical industries. Moreover monolaurin, the monoglyceride derivative of LA have even more potent antimicrobial properties against lipid-coated RNA and DNA viruses, numerous pathogenic gram-positive bacteria, and various pathogenic protozoa reported by Paul May (2012)⁸. In addition, James and Rahman (2005)²⁴ reported that coconut oil can be used as a skin moisturizer, as engine lubricant and even transformer oil. Even the acids derived from coconut oil may be used as an herbicide was also reported²⁴.

Antifungal activity:-

In a recent study, Ogbolu DO *et al.*(2007)²⁵ reported that coconut oil had also shown antifungal activity against *Candida* species at 100% concentration isolated from clinical specimen compared to fluconazole. Coconut oil hence should also be used in the treatment of fungal infections in view of emerging drug-resistant *Candida* species. Shari Lieberman *et al.* in 2006 reported that monolaurin- a derivative of LA may have the ability to kill or inactivate a number of fungi (several species of ringworm), yeasts, and protozoa²⁶. Even several studies have also reported that *Candida albicans* and the protozoan parasite *Giardia lamblia* may be killed by monolaurin²⁶⁻³⁰.

Antiviral activity:-

Enig M. (1998)³⁰ reported that Lauric acid derivatives- monolaurin may deactivate some of the viruses that include Human Immune-deficiency Virus (HIV), measles, Herpes simplex-1, cytomegalovirus, visna virus, and vesicular stomatitis. A study conducted by Tayag E *et al* (2000)³¹ where the objective was to document the viral load of HIV viruses in patients using monolaurin at two doses (2.4 g versus 7.2 g) with 50mL of coconut oil as doses. There were

groups with 15 patients in each group. The study was conducted for 6 months with documentation of virus present at the beginning of the study, after 3 and 6 months respectively. At the end of the study the presence of virus was found significantly low in three patients, two from coconut-oil group and one from lower dose (2.4g) of monolaurin group³². Monolaurin can also be held responsible for inactivation of opportunistic infections and other illnesses such as chronic fatigue syndrome and immune dysfunction syndrome in HIV-positive individuals²⁶.

Anticancer activity:-

LA is known to show anticancer activity by reducing glutathione level in cells which is exactly what the cancer cells need to protect themselves from- the increased oxidative stress which induces apoptosis. Recently Fauser JK *et al.* (2013)³² reported that Lauric acid induced apoptosis in Caco-2 ($p < 0.05$) and IEC-6 cells ($p < 0.05$) by modifying glutathione (GSH) levels. This occurred when LA modified the phases of cell cycle in Caco-2 and IEC-6 intestinal cell lines and generated reactive oxygen species (ROS) compared to butyrate, a short chain fatty acid.

Decreases Total Cholesterol level and Cardiovascular Disease:-

Saturated fats have the ability to increase cholesterol level in our body and so consumption of it in daily life should be avoided. In the recent world, hence all the people are suggested by doctors to avoid consumption of saturated fats as much as possible in food stuff for living healthy life. However, MCT saturated fats have the power to increase good cholesterol i.e. high-density lipoprotein (HDL) in blood. Thus consumption of MCT products by people who are sensitive to cholesterol may decrease the risk of coronary artery disease in them and even may actually help to decrease level of total blood cholesterol¹, in contrast to long chain triglyceride saturated fat that enhances blood bad cholesterol i.e. low-density lipoprotein (LDL) and increase the level of triglycerides in blood serum. Some studies also suggested that VCO shows the potential beneficiary effect in lowering lipid levels in serum and tissues and LDL oxidation by physiological oxidants³³.

Decreases Body weight:-

Although many recent studies reported that use of coconut oil as dietetic supplementation does not cause dyslipidemia and seems to promote a reduction in abdominal obesity of women presenting waist circumferences (WC) > 88 cm (abdominal obesity). However LA directly used as dietetic supplement decreases the body weight^{1, 34}. An article from nutrition review suggested that MCTs have fewer calories per serving, roughly 8.3 calories per gram rather than the standard 9 calories per gram compared to long-chain triglycerides, the type of other saturated fats¹. Many researchers also suggested that a diet rich in MCTs may potentially help to decrease body weight as a result of choosing to consume fewer calories, as well as a reduction in waist circumference compared to a diet rich in long chain triglycerides¹.

Conclusion:-

Lauric acid (LA) being one of the major components of coconut oil and a MCT component which may be having the ability to decrease cholesterol level and decrease body weight. Even LA may be effective against many microorganisms and can be taken on a daily basis, given that evidence suggests it does not create antiviral or antibacterial resistance like coconut oil because approximately 50% of total fat of coconut oil consists of LA. The main point of this review is that LA is a very common source of food, inexpensive, non-toxic, safe to handle and easily found from natural source. To isolate in huge amount can be very cost efficient and may be used as a drug active agent against various diseases in future. But more clinical studies are needed to approve LA as a supplement for human health.

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