Benefits of Using MCT Oil in E-Liquids

The advent of E-cigarettes has been gaining popularity because of its simple mechanism. Eliquid or E-juice is filled up in the cartridge of the E-cigarettes and when the E-liquid is heated up, it converts to aerosol and E-cigarettes users inhale the vapor. [1] E-liquid or E-juice is termed vape juice. The usual vape juice contains four ingredients: a propylene glycol (PG) or vegetable glycerin (VG) base, nicotine, water and flavorings. [2] This usual composition of Ecigarettes has some health drawbacks. The most usual base of E-cigarettes is Propylene glycol (PG). PG is a bland and flavorless substance and does not interfere with the flavor of the eliquid. Consistent users of PG based E-cigarettes often experience drying of the mouth and throat, as PG absorbs moisture (humectant). Throat hit effect is similar to tobacco cigarettes for PG based E-cigarettes. In rare instances, some e-cig users reported allergic reactions with PG based E-cigarettes. [2]

Vegetable glycerin (VG) is a considerably thicker solution and is difficult to absorb by the polyfill fabric present inside the cartridge and can be a major drawback of VG. Vegetable glycerin (VG) is also sweet in taste and this interferes with the taste of the E-liquid. Many users choose a PG/VG mix to solve all these difficulties present in single based vape juice. [2]

Experimental research data has shown that glycerol induces stiffness in the soft covering of the lungs. [3] The functional unit of the lungs is termed as alveoli. During inhalation and exhalation, the alveoli inflate and deflate accordingly. The inflation and deflation of alveoli largely depends on surface tension. The alveoli are coated with surfactant (also known as lung surfactant) to minimize the surface tension. [4] The lung surfactant become stiff in the presence of glycerol and increases surface tension. [3] Increased surface tension creates difficulty in inflating the alveoli and requires more effort to inhale. [4] Vegetable glycerin (VG) is a natural glycerol and can create this same problem with high concentration. Therefore, the concentration of VG acting as a carrier in vape juice, is a very crucial factor for long-term use.

These days MCT oil made of medium chain triglycerides (MCT) replaces propylene glycol (PG) or vegetable glycerin (VG) base in vape juice. Previously we had a misconception that oil or rather lipid is bad for health. But the gradual development of nutritional research explains that lipids are essential for physiological functioning. More detailed descriptions were obtained from Nutraceutical and Specialty Lipids and their Co-Products presentation, which illustrated the nutritional value and health aspects of fats and oils. However, it is obvious that the source and process of lipid extraction are important for getting the beneficial health effect. [5] MCT is a natural constituent of many food items. Some of the food items which contain MCT are coconut oil, palm oil, goat milk and other mammalian milk including human. The two primary
Ingredients in MCT are caprylic and capric fatty acids. [6] The synthesis of MCTs follows a hydrolysis of coconut oil followed by the fractionation of the fatty acids. In this process, a mixture of medium-chain fatty acids (MCFAs) is obtained, i.e., C6:0 (1 to 2%), C8:0 (65 to 75%), Cl0:0 (25 to 35%), and C12:0 (1 to 2%) MCFAs. MCTs are more rapidly and completely hydrolyzed due to their smaller molecular structure. This facilitates the action of pancreatic lipase. [7] MCT is a light yellow, translucent liquid at room temperature without any significant odor. [6]

The molecular structure of **Caprylic acid** is made of eight-carbon saturated fatty acid, [8] whereas the molecular formula of **capric acid** is CH3(CH2)8COOH. [9] Both of these components individually may have some clinical benefits. For example, caprylic acid is thought to have an anti-obesity effect, as some MCTs assist in the excess calorie burning process; [8] whereas capric acid has anti-seizure effects by inhibiting excitatory neurotransmission. [9]

The weight management property of caprylic acid lacks enough study data, but experts suggest that after absorbing the MCTs into the systemic circulation, they circumvent the digestive procedure and also exert quick energy release due to their thermogenic effect (calories burning effect). Therefore, more caloric exertion leads to a lessened amount of MCT storage in the fat cells and assists in the reduction of body fats. MCT behaves differently than other conventional fats. [7]

A unique molecular structure composed of only 6 to 10 carbon links differentiates MCTs from other dietary fats, including Long Chain Fatty acids. [10] Recently a wide range of clinical applications of MCTs and modified MCTs were analyzed and the study supported the beneficial effect of MCTs in hyperalimentation, deficiency in the carnitine system, epilepsy, obesity, and other special areas. [7]

**Clinical Use of MCTs**

**Fat malabsorption**

Malabsorption of fat can be solved by adding MCTs, due to their smaller molecular structure which can easily be soluble in water and does not follow complicated digestion processes like other fats. [7] The high water solubility makes an easy transport of MCT from gut wall to the liver through portal circulation. Few amounts of MCTs in the hepatic cells convert into ketone bodies. These ketone bodies are utilized by muscles for obtaining energy. Therefore, the maximum amount of MCTs are utilized due to conversion in liver cells, and a very small amount is left to be stored as fat. MCT oil as a dietary supplement is available in different dosage forms such as powder, gel caps, or oil. [6] Thus, MCTs play a great role in human therapy, particularly in cases of disturbed digestion, absorption, or transport of dietary fats.

**Gallbladder disease**

In vitro, in vivo study and even the laboratory investigational results showed that the medium-chain monodiglycerides are effective in the dissolution of gallstones and are also safe for human use. The clinical trial also worked to prove the efficacy of medium-chain monodiglycerides containing the drug in the USA (Capmul 8210, Stokely-Van Camp, Inc, Indianapolis, IN; US patent 4,205,086, May 27, 1980). Medium-chain monodiglycerides also useful to treat cholesterol-related choleithiasis. [7]
Antimicrobial Properties

MCFAs have an antimicrobial effect, specifically inactivated microorganisms, including bacteria, yeast, enveloped virus and fungi. MCTs can reduce the risk of development of a number of infections. [5]

MCTs as Energy provider and ketogenic properties

MCTs are a good source of energy due to their fast oxidizing properties and exert many ketone bodies. The produced energy is well distributed to the whole body, including to the liver and the extra-hepatic tissues. The ketone bodies synthesized during energy production do not cause any harm. The synthesized ketone bodies are utilized by the extra-hepatic tissues. MCTs assist in providing increased energy that is required after major surgery. It is also useful for normal growth or to treat retarded growth. Therapeutic products are available for solving the retarded growth of newborns or children, but detailed study data require to establish their efficacy and safety during pregnancy. [7] This high energy supply is also required for athletes. Animal studies showed that MCTs can increase physical stamina by enhancing metabolic enzymes (3-oxo acid CoA-transferase, citrate synthase and malate dehydrogenase) associated in the Krebs cycle (the primary energy production mechanism in the body). [10]

Anti-aging properties

The calories released from MCTs are quickly burned as fuel and do not store in body tissues as fat. The produced fuel is utilized by all the tissues and organs, as the energy rapidly crosses the mitochondrial double layer. Energy deficiency is one of the prime factors for aging. The enhanced energy level with MCTs can counteract the deficit production of energy and may delay the aging. [7] The human brain needs maximum energy to function properly. Deficiency of energy supply causes brain aging. MCTs produce ketones that can be utilized by the brain and thus aging of the brain can be prevented. [10]

Anticonvulsive properties

The ketogenic properties of MCTs have advantages as alternative anticonvulsive therapy. MCTs containing preparations are not unpalatable and are difficult to prepare and administer like other ketogenic diets. MCTs containing products are useful for treating cases of resistance to usual drugs and also for intolerance to prescribed medication. [7]

Hyperlipidemias

In some literature it has been documented that MCTs can decrease cholesterol levels in blood and liver, but more research based studies are required to establish this effect. [7]

Deficiency of the carnitine system

Experts expect that MCTs are useful for treating the deficiency of carnitine or carnitine palmityl transferase, which plays a crucial role in skeletal muscle. The systemic deficiency of carnitine
also negatively affects the cardiac muscle, liver, and kidney functioning. [7]

**Obesity**

There are several evidence-based reports which show that MCTs may have a role in controlling obesity, as preclinical studies established that MCTs can create a reduction in body weight. Further positive correlations support the weight management capacity of MCTs. These include:

- Low-calorie content than other fats including LCTs. (MCTs contain 8.3 calories per gram; whereas LCTs contain 9 calories per gram) [7]
- Fast oxidizing capacity of MCTs
- Low tendency of MCTs to store in the adipose tissue as body fat
- MCTs are not also hyperlipidemic. [7]
- MCTs enhance metabolism rate to burn more calories. [10]
- The principle of the weight management diet or Atkins Diet is to produce ketones and that can be achievable by consuming MCTs. [10]
- Small-scale clinical trial with healthy volunteers showed the additional benefits of substituting MCTs with a high-fat diet and to less caloric intake due to MCTs suppressing appetite. [10]

**Cardiac Health improvement**

It is assumed that atherosclerosis is the major risk factor associated with cardiac problems and that may be prevented by consuming MCTs. An animal study showed that MCTs are effective to lower the serum cholesterol level and the cholesterol level in the liver and other tissues. MCTs have anti-oxidant properties and anti-coagulation effects. Diabetes increases the risk of cardiovascular disease. MCTs have a meager hypoglycemic effect. In Sri Lanka, coconut oil is primarily used for dietary purpose and the cardiac disease related mortality rate is 1 per 1,000,000. All these factors indicate that MCTs are good for cardiac health. [10]

**Immunity booster**

An animal study conducted by Kaunitz. et.al. showed that the pathologic condition of autoimmune kidney disease can be altered with intake of MCTs. Therefore, it is hypothesized that MCTs can alter autoimmune conditions caused by immunity problems, which is one of the prime bothersome physiological conditions associated with aging. [10]

**Therapeutic benefits**

One of the origins of obstructive jaundice, biliary cirrhosis, pancreatitis, cystic fibrosis, celiac disease, Whipple’s disease, Crohn’s disease, regional enteritis, and malabsorption in neonates is impaired or damaged lipid (fat) metabolism. MCTs are effective to prevent or improve such health issues. [10]
The evidence, as discussed above, supports that MCT oil has some beneficial health effects. These benefits can be achieved through adding MCTs in vape juice, which provide a unique taste and aroma. This new alteration of vape juice composition is more enjoyable for e-cig users.

MCT oil used in vape juice is delivered in physiological compartments via the inhalation route. Inhaling the MCT oil though vape juice is an innovative way to consume this and to obtain mentioned beneficial health effects other than conventional way like oral or other invasive (injection) routes. The advantages of MCT oil intake through vape juice is discussed in the section below.

The chemical nature of MCT described in Nutraceuticals and Speciality Lipids and Their Co-Products; page 32 mentions that the nature of MCT oil is similar to carbohydrates with smaller molecular size and has hydrophilic tendencies. Any drug which is required to be provided through the inhalation route should match aerodynamic diameters i.e. in between 1 μm to 3 μm. Both hydrophilic and hydrophobic nature of drugs can be absorbed through lungs, although their rate of absorption differs. The advantages of the inhalation route over another conventional routes such as oral or parenteral (through injection) are as follows: [11]

- Both small and macromolecular drug particles can be deliverable through an inhalation route. MCT oil contains medium carbon chains and is easily administered through an inhalation route.
- More rapid absorption of MCT oil into the systemic circulation can be possible through an inhalation route.
- The bioavailability of MCT oil is higher in comparison to other non-invasive routes (oral).
- Inhaling MCT oil provides the bioavailability of the pulmonary epithelium, which cannot be possible with any other route.
- Great user compliance.
- Metabolism of MCT oil through the oral route is much higher and chances of alteration of the drug become greater due to enzyme secretion from the gut and liver. But maximum MCT oil is unaltered in the lungs due to a fraction of metabolism that takes place there.
- Rapid absorption is possible through the inhalation route and provides a quick physiological response.

There may be some concern about the risk of development of lipid pneumonia by using MCT oil as a carrier. In the section below, we discuss the low risk of development of lipid pneumonia with MCT oil.

**What is Lipid Pneumonia?**

Lipid pneumonia is the condition in which lipids accumulate endogenously or exogenously in the alveoli of the lungs. The reaction of the individual host tissue depends on the chemical characteristics of the inhaled substances. The symptoms vary from individual to individual with varying degree ranging from asymptomatic to fatal. [12] Lipid Pneumonia is classified into two groups depending on the site of accumulation of the lipid.
• **Exogenous lipid pneumonia:** This develops due to aspiration or inhalation of animal fats, vegetable oils or petroleum jelly.

• **Endogenous lipid pneumonia:** this develops due to respiratory system disorders, including bronchial obstruction, pulmonary alveolar proteins, chronic pulmonary infection or fat accumulating diseases. [13]

**MCT does not cause Lipid Pneumonia**

The exogenous lipid pneumonia can be developed by inhalation of animal fats, vegetable oils or petroleum jelly. MCT is a medium chain triglyceride, so the obvious question is: - Can vape juice, carried by MCT oil, cause lipid pneumonia?

One of the prime cause of Exogenous Lipid Pneumonia is the complication that is related to fat malabsorption. Most fats have the problem of malabsorption due to their physicochemical property. One of the exceptions is MCT oil. MCT oil is fatty in nature, but the physiochemical property of MCT consists of MCFAs (Medium Chain Fatty Acids). The MCFAs are responsible for maximum benefits of MCT oil - avoiding lipid pneumonia. The presence of MCFAs provides a significant effect of ease of absorption of MCT oil. Therefore, the complications of mal-digestion and mal-absorption of other fatty substances does not occur with MCT oil. [5] MCT oil does not cause lipid pneumonia due to the following reasons:

• The smaller molecular size of MCTs is more quickly and completely hydrolyzed without altering pancreatic secretions. The hydrolyzed products are rapidly absorbed like glucose. MCTs do not behave like other conventional fats, but more likely as carbohydrates. [5]

• The relatively small length carbon chain makes MCTs more water soluble and hydrophilic in nature. [7]

• MCTs usually absorb as fatty acids and rarely as monodiacylglycerols due to the chemical reaction assisted by bile salts and pancreatic lipase during hydrolysis. Even MCTs can change into triacylglycerols with insufficiency of bile salts and pancreatic lipase, which is not possible with other triglycerides. The synthesized triacylglycerols are further hydrolyzed with intestinal lipase. Thus MCTs are completely hydrolyzed and absorbed. The risk of mal-digestion and malabsorption with MCTs will usually not take place. [7]

• Moreover, MCTs do not require lipolysis and micelle formation like other triglycerides. The intact absorption of MCTs take place through intestinal epithelial cells and is liberated by portal circulation. This does not involve lymphatic systems like long chain fatty acids. [14]

• MCFAs are not significantly incorporated into chylomicrons. Chylomicrons are composed of apo B48 (Apolipoprotein B-48) triglycerides and malformation of this is responsible for Abetalipoproteinemia. [14]

**Contraindications**

• Diabetic patients should not use MCTs, as they have ketogenic effects.

• MCTs should not be advisable for patients with ketosis or acidosis, as their extra-hepatic tissues are unable to saturate the excess amount of ketone bodies. The excess amount of ketones does not
produce energy, but worsens the metabolic acidosis and accelerates the breakdown of homeostatic mechanisms.

• MCTs are not advisable for cirrhosis patients, as altered metabolism may be dangerous for brain activity. [7]

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