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Article #8 - The Health Benefits of Medium Chain Triglycerides in Goat Milk

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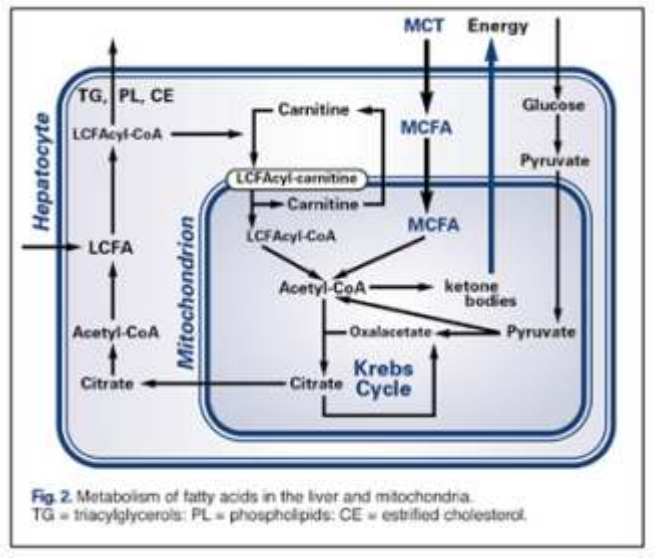
Amongst the numerous known benefits of goat milk hides a little recognized yet powerful nutrient: medium chained triglycerides, or MCTs. In addition to its high essential fatty acid content compared to cow milk, goat milk also contains 30-35% MCTs while cow milk contains 15-20%. These fatty acids have many therapeutic benefits for a variety of conditions including exercise performance, weight management, diabetes, and nutrient malabsorption. In this article, we explore the benefits of the MCTs in goat milk that contribute to its stake in the natural functional food and healthy dairy alternatives category.

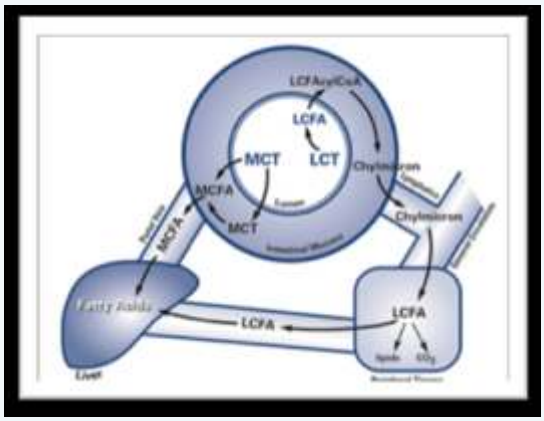
Medium Chain Triglycerides
Dietary fats are molecules composed of individual carbon atoms linked into chains ranging from 2 to 22 carbons in length. While long chain triglycerides (LCTs) range from 12 to 18 carbon atoms, Medium-chain triglycerides (MCTs) are composed of 6 to 10 carbon links.
Fig.1. Transport of MCT across the mitochondrial membrane. Note the lack of a carnitine shuttle as opposed to LCT.



(Dean & English, 2012)

The American diet is typically rich in LCTs, which require structure modification and the presence of a carnitine shuttle in order to be transported into the mitochondria of the cell, where it is then further broken down for storage and energy production via the Kreb's Cycle **(Figure 1)**. In contrast to LCTs, the shorter chain length of MCTs gives these fats a nutritional advantage in terms of absorption and energy production. These triglycerides are relatively water soluble and, hence, rapidly hydrolysed and absorbed. They are able to passively diffuse from the gastrointestinal tract to the portal system without the need for modification or the presence of carnitine, which contributes to the energy-enhancing properties of MCTs **(Figure 2).** In addition, the fat-digesting enzyme, lipase, is able to break down the ester linkages of MCTs much faster than LCTs. Furthermore, MCTs do not require the secretion of pancreatic bile salts for digestion. As a result, there is an excess of acetyl-CoA generated which leads to the production of ketone bodies. MCTs are therefore commonly used to treat patients with various disorders including malnutrition or malabsorption syndromes as they are rapidly absorbed and promote the absorption of other dietary nutrients (Kompan and Komprej, 2012; McCollough, 2003).

Fig.2. Digestion & transport of fats. Note greater absorption efficiency of MCTs vs. LCTs, resulting in more rapid energy production.



(Dean & English, 2012)

The MCTs in Goat Milk

Triacylglycerols (TAGs) make up the largest portion of milk lipids (nearly 98%), and are present in the form of globules. The TAGs found in goat milk are mainly short- and medium chain length, and the average fat globule size is smaller than that of cow milk globules. These features make the fat in goat milk more advantageous for digestibility and more efficient in lipid metabolism compared with cow milk fat (Park et al., 2007).The names of MCTs in edible foods and oils are caproic acid (hexanoic acid, C6:0), caprylic acid (octanoic acid, C8:0) and capric acid (decamoic acid, C10:0). These are the predominant fatty acids found in goat milk, thereby giving the milk its name: caprine milk

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The Health Benefits of MCTs

Anti-Convulsive Effects of Caprylic Acid

Seizures that are resistant to standard medications are a major clinical issue. For such cases, the ketogenic diet has been found to be one of the most effective therapies. As its name indicates, this diet produces ketone bodies and although the exact mechanisms of the diet is unknown, ketone bodies have been thought to help protect against the convulsions and epileptic effects associated with drug-resistant epilepsy. Interestingly, research has also found that a medium-chain triglyceride ketogenic diet may be an even more effective therapy than the classic ketogenic diet alternative (Liu and Wang, 2013). As mentioned above, the consumption of MCTs leads to the rapid production of ketone bodies, which would thereby add to the ketone production of a normal ketogenic diet, contributing further to the anticonvulsant and antiepileptic effects (Liu and Wang, 2013; McNally and Hartman, 2012).

Metabolic Syndrome & Diabetes

Metabolic syndrome involves a variety of conditions including hypertension, hyperglycemia, excess abdominal fat and high cholesterol levels, which occur together and increase the risk for diabetes, stroke and heart disease. Dietary lipids have been found to contribute to the development and prevention of this multifactorial disease and MCTs have been used for the dietary treatment of the syndrome since the 1950s due to their metabolic properties. Experimental human and animal studies show that the enhanced thermogenesis and fat oxidation of MCTs prevent fat deposition and preserve insulin sensitivity in patients with type-2 diabetes (Nagao and Teruyoshi, 2010).

Specifically, the anti-diabetic properties of MCTs have also been reported in both animal and human studies. Results indicate that a diet containing MCTs lead to less body fat accumulation and better glucose tolerance in rats compared to diets containing LCTs. Furthermore, research has shown that long chain fatty acids impair insulin sensitivity and lipid metabolism, whereas medium chain fatty acids seem to protect from lipotoxicity and insulin resistance without caloric restriction Similarly in human trials, the

consumption of a diet containing MCTs increased insulin-mediated glucose metabolism in both diabetic and non-diabetic subjects (Nagao and Yanagita, 2010).

Energy & Exercise Performance

In recent years MCTs have gained popularity with athletes seeking to increase energy levels and enhance endurance during high-intensity exercise, in addition to serving as an alternative energy source for athletes on high-protein, low carbohydrate diets. Studies have shown in recreational athletes, 2 weeks of ingesting food containing 6g of MCTs per day suppressed increases in blood lactate concentration and the perception of exertion during moderate-intensity exercise. Results also indicate that the ingestion of MCTs extends the duration of subsequent high-intensity exercise at levels higher than those achieved by ingestion of LCT-containing food (Nagao and Yaganita, 2010).

Weight Control & Blood Lipid Metabolism

Research has shown that MCTs have three key properties that make them an ideal fat alternative for those wanting to control their weight. The first property is the fact that these fatty acids provide around ten percent fewer calories than the more common long chain fatty acids (8.3 calories per gram for MCTs versus 9 calories per gram for LCTs). In addition to providing fewer calories, MCTs are also not destined to be deposited as fat in the body as much as the longer chain triglycerides and are efficiently converted into fuel for immediate use by the organs and muscles. Finally, MCTs have been shown to enhance the body's fat burning process.

A crossover randomized controlled trial published in the *Journal of Obesity Research* comparing the effects of diets rich in MCTs or LCTs on the body composition, energy expenditure, substrate oxidation, subjective appetite and ad libitum energy intake in 24 healthy, overweight men found MCTs to increase energy expenditure and decrease adiposity in the subjects. The participants followed the trial consuming MCT or LCT for 28 days each, and measurements were taken at baseline and after 4 weeks of both dietary interventions. The diet rich in MCTs lead to a greater loss of upper body as well as overall adipose tissue reduction, which is thought to be due to a rise in energy expenditure, fat oxidation and greater fecal fat excretion with the MCT diet relative to a diet rich in LCTs. In addition, an animal study conducted by Shinohara et al. found that MCT feeding suppressed lipogenesis and enhanced lipolysis in adipose tissue, thereby resulting in reduced adiposity. Furthermore, in another a human study, healthy subjects consuming 1.7g of MCTs daily at breakfast for 12 weeks had significant decreases in body weight, amount of body fat, subcutaneous and visceral fat at 8 weeks in comparison with the LCT group (Nagao and Yaganita, 2010).

Appetite Control

Studies have found that diets high in MCTs seem to suppress appetite, which can also contribute to their effects on weight management. Wymelbeke et al. (1998) carried out a study on 12 healthy male volunteers aged 19-24 years old with normal body weight. The researchers compared the effects of 4 high-carbohydrate breakfasts supplemented either with a fat substitute or with fat as monounsaturated LCTs, saturated LCTs or MCTs. The results showed that MCTs decreased ad libitum food intake throughout the day, while no differences were observed between the monounsaturated and saturated LCT conditions. The observed effects are thought to be caused by the more rapid satiating effect in the MCT group as a result of increased ketone body production, which have been shown to decrease food intake. Furthermore, the consumption of MCTs has also been proposed to reduce the concentrations of the hunger hormone, ghrelin, thereby contributing to their satiating effects.

Malabsorption Disorders

Protein and energy malnutrition are serious issues for health care facilities in developing countries, as well as for those suffering from malabsorption diseases. Cow's milk is expensive to produce and not as readily available in developing countries, whereas goat's milk is far more abundant in many areas. Therefore the use of this dairy alternative as part of the treatment for malnutrition has been thoroughly investigated.

As MCTs are more easily digested and absorbed without the need for modification or bile salts as LCTs do, patients suffering from malnutrition or malabsorption syndromes are treated with MCTs. Fatty liver is a common feature of children with protein malnutrition. Kuwahata et al. (2011) found that providing MCTs to rats with protein malnutrition reduced the accumulation of triglycerides in the liver, thereby suggesting that MCT supplementation may be beneficial to prevent fatty liver in malnourished children. Other in vivo studies include research conducted in Madegascar involving 30 malnourished children aged 1 to 5 years investigating the effects goat's milk versus cow's milk consumption on their rehabilitation. The children receiving the goat milk in their diet surpassed those on cow milk in weight gain, height, skeletal mineralization and serum contents of vitamin A, calcium, and other minerals, indicating that the utilization of fat and protein was greater in the goat milk group (Razafindrakoto et al., 1994). Similarly, in an Algerian study of 64 infants suffering from malabsorption syndromes, the replacement of cow milk with goat milk in the diet resulted in significantly higher rates of intestinal fat absorption (Haenlein, 2004). Furthermore, in another study investigating the differences between fat metabolism and use in malabsorption syndrome, researchers observed rats with a resection of 50% of their distal small intestine and control animals (transected). The animals were placed on a goat milk or cow milk diet, and at the end of the trial, the digestive utilization of fat was much higher in the transected and resected groups receiving the goat milk diet. These results of increased efficiency in fat utilization have been attributed to the high levels of medium chain triglyceride content present in caprine milk (Alferez et al., 2001).
In addition to malabsorption disorders, evidence also suggests that MCTs are a useful fat substitute for those who have difficulty digesting fat. In this disorder, fat is not digested, but passes unchanged through the intestines, and the body is deprived of calories as well as fat-soluble vitamins. This makes MCTs potentially beneficial for people with AIDS, who need a way to gain weight but cannot digest fat easily. A double-blind, placebo-controlled study on 24 patients with AIDS suggests that MCTs may help improve AIDS-related fat malabsorption. The subjects of this study were divided into two groups: on receiving a liquid diet containing normal fats, whereas the other group received mostly MCTs. After 12 days, the participants on the MCT formula showed significantly less fecal fat excretion and improved fat absorption than the other group (Craig et al., 1997; Caliari et al., 1996).
Similarly, as the body depends on enzymes from the pancreas to digest fat, a study has found that patients with inadequate pancreatic function due to chronic pancreatitis appeared to be better able to absorb MCTs than ordinary fatty acids (Wanke et al., 1997).

Conclusion

Fat is an essential nutrient contributing to the normal health and functioning of the body. However, as we have seen, there are various disease states that may prevent the efficient digestion and utilization of fats and fat soluble nutrients, mainly in the form of LCTs. Studies have shown that the consumption of MCTs is a beneficial and therapeutic fat source for such disorders. Goat milk is particularly rich in these shorter chain triglycerides, thereby making it a natural and healthy dietary fat source that is effective in relieving a variety of health conditions.

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