MCTS IN DOGS: BEYOND THE BRAIN (A REVIEW)

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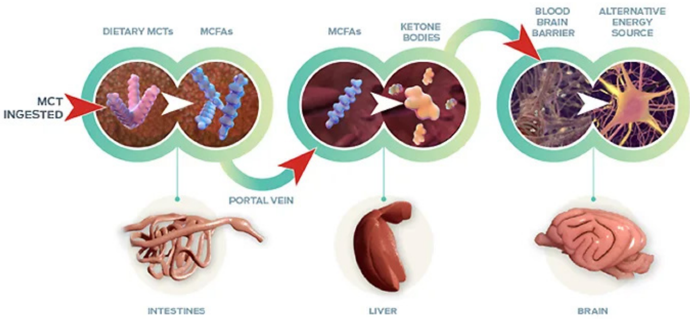
In the realm of pet nutrition targeting cognitive support, the beneficial effects of medium chain triglyceride (MCTs) supplementation are myriad and well documented. Most notably, MCTs have demonstrated powerful neurological benefits in the support and management of ageing-related conditions, cognitive dysfunction syndrome (CDS), and canine epilepsy. Yet the influence of this supplement extends beyond merely cognitive health. While still an emerging field, deploying MCTs in targeted gastrointestinal and cardiac health nutrition shows both promise and ambiguity. This review brings those findings to light, revealing the diverse effects of MCT supplementation in areas further afield from purely neurological health.

Background

MCTs are lipids comprised of fatty acids 6-12 carbon atoms in length and are most commonly found in tropical oils such as palm kernel and coconut. They comprise medium chain fatty acids (MCFAs) such as caproic, caprylic, capric and lauric acid (though lauric acid also emulates long-chain digestive behaviour) and have been utilised in both human and companion animal nutrition due to their health benefits. One of the stark differences between long chain triglycerides (LCTs) and MCTs lies in their method of digestion. Long chain triglycerides require pancreatic biliary lipolysis and emulsification to be ultimately utilised as free fatty acids. After first being broken down by pancreatic lipase and then absorbed into micelles, these eventually break down and release fatty acids and monoglycerides into the lymphatic system. This resource-intensive procedure stands in distinct contrast to the direct absorption of medium-chain triglycerides (MCTs), which bypasses the need for bile acid or pancreatic enzymes, and results in their direct bloodstream uptake into the portal vein and on to the liver (Shah & Limketkai, 2017).

Compared to long chain fatty acids (≥13 carbon atoms in length), the shorter carbon chain length of MCTs plays a significant role in their health benefits.



Digestion and metabolism of Medium Chain Triglycerides.

MCFAs (the fatty acids that constitute MCTs) are water-soluble and can be digested more easily and absorbed more rapidly in the stomach, into the bloodstream and transported to the liver. In turn, they can then be used as an immediate source of energy. This process also makes them less likely to be stored in adipose tissue (McCarty & DiNicolantonio, 2016), a factor that can contribute to potential weight gain. Bearing this in mind, MCT oils that have undergone purification feature a higher MCFA content and therefore offer a greater potential benefit. Consequently, given these differential aspects, as animals age, MCTs provide an alternative energy source for a range of organs requiring additional support throughout the body.

On Ageing, Cognitive Support and Epilepsy Management

In terms of ageing-related conditions, cognitive support, and epilepsy, MCTs have emerged as a crucial nutritional intervention. In canines with idiopathic epilepsy, robust evidence has highlighted the striking efficacy of MCTs in reducing the frequency of seizures (Molina et al., 2020) and number of days with seizures (Law et al., 2018). Beyond their anticonvulsant properties, MCT-enriched diets have also exhibited a positive impact on behaviour (Verdoodt et al., 2022) and cognition (Berk et al., 2021) in these dogs. Discoveries such as these have solidified these diets as a cornerstone in the management of canine epilepsy (Berk et al., 2020; Han et al., 2021; Law et al., 2015). The vast body of scientific research also highlights the profound impact of MCTs on cognitive function in ageing and neurologically challenged dogs. With MCT supplementation acting as an alternative energy source for the brain, findings have unveiled that MCTs significantly enhance brain function in aged dogs and align with the broader concept of MCTs as valuable dietary additions for cognitive preservation (Leung et al., 2020). Furthermore, an investigation into the cognitive benefits of MCT-rich diets demonstrates that dogs fed a diet containing 5.5% MCTs exhibit improved performance on learning tasks, and these cognitive benefits intensify with extended supplementation, substantially improving executive function and attention (Pan et al., 2010). In the context of cognitive dysfunction, a recent study revealed that a commercial diet enriched with 6.5% MCTs, together with a targeted nutrient blend, proves effective in mitigating the behavioural signs of CCDS (canine cognitive dysfunction syndrome) (Pan et al., 2018). Meanwhile, further findings have shown that sustained MCT supplementation notably boosts cognitive abilities in senior dogs, addressing the concern of cognitive decline in ageing canine populations (Manteca, 2011), with another study finding that MCT oil supplementation in aged dogs increases fatty acid oxidation and ketone body production, crucial factors that contribute to cognitive preservation (Taha et al., 2009). Additionally, the benefits of MCTs in managing clinical signs of CCDS in dogs have been elucidated, indicating substantial enhancements in cognitive domains (Pan et al., 2018). This suggests that MCT supplementation may slow cognitive impairment progression in ageing dogs and holds promise for mild to moderate CCDS (Cline et al., 2011).

Studies investigating cognitive effects of MCTs have also unearthed compelling discoveries in other areas of health, with a 2015 study shedding light on MCTs' capacity to regulate nitric oxide signalling, with potential implications for dogs with degenerative mitral valve disease (DMVD) (Li et al., 2015). These discoveries point to the broader influence of MCTs within other systems of the canine body.

On Gastrointestinal Health

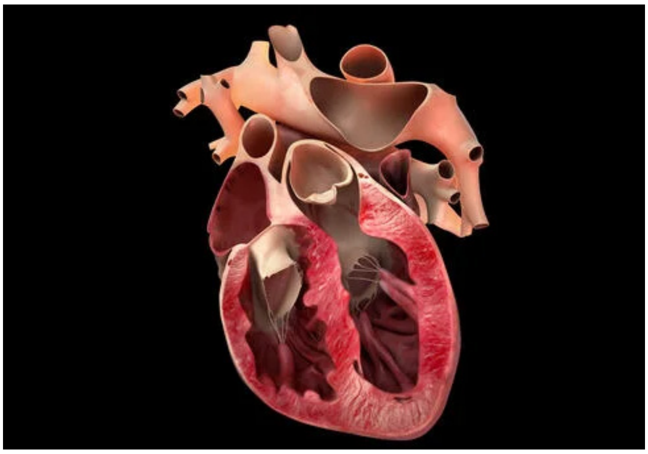
Delving into the gut, investigation has yielded several promising discoveries. MCTs have been shown to modulate intestinal inflammation and cause less damage than LCTs in an animal model of ileitis (Tsujikawa et al., 1999), and therefore might help to reduce intestinal inflammation in canine inflammatory protein-losing enteropathy (Kathrani & Parkes, 2022). Further to this, due to the rapid conversion of MCTs into energy in the liver, this gastrointestinal influence not only offers potential benefits in supporting those dogs with DMVD (Liu, 2015), but also suggests broader influences that require further exploration. For instance, in dogs experiencing diarrhoea due to fat malabsorption that need a highly concentrated source of energy, MCTs can meet this requirement. MCT-enriched diets have been found to enrich nutritional status, and may also benefit dogs lacking bile acids and provide a more viable digestive option for canines with exocrine pancreatic insufficiency (when compared with a commercially available diet containing LCTs) (Trapping, 1997). Among studies investigating the effects of dietary fat composition and MCT supplementation in healthy dogs, one paper focused on serum concentrations of hormones cTLI, cPLI, and gastrin (all involved in gastrointestinal digestion), finding no substantial influence from dietary fat content or the addition of supplemental MCT oil (James et al., 2009). Furthermore, caution may need to be exercised when employing MCT supplementation in the management of intestinal lymphangiectasia. Contrary to their benefits in humans (where MCTs are utilised to boost caloric intake without increasing lymph flow), a study found that absorption into the lymphatic system still occurred, ultimately contributing to the make-up of lymph. However, physiological differences between the species must be borne in mind, and these findings should be viewed with scepticism as they originate from a dated study on just seven dogs (Jensen et al., 1994).

To be of greatest benefit, researchers have emphasized that the inclusion of MCTs in diets should be tailored to individual cases, stating that if MCTs are indeed included in a diet, clinical assessment should focus primarily on improvements in gastrointestinal signs, body condition, and various laboratory parameters, including serum albumin, globulin, and cholesterol levels (Kathrani, 2023). In another study, the potential hyperlipidaemic effects of a high intake of MCTs in dogs were underscored. Strikingly, MCTs offer unique advantages, such as quick energy conversion, but their role in diets should also be approached with an understanding of their potential to elevate plasma cholesterol levels (Van Dongen et al., 2000) and what consequent effect this may have on pancreatic, liver and ocular health (Johnson, 2005; Xenoulis & Steiner, 2010). Another notable effect of MCT supplementation was its ability to increase concentrations of the protein hormone adiponectin (Mazaki- Tovi et al., 2014), which in turn can influence the secretion of gastric acid, the motility of the stomach and intestines, and nutrient absorption. This hormone can also modulate immune and inflammation responses in the gastrointestinal tract, thereby suggesting its influential role in the management of inflammatory bowel diseases (Muñoz-Prieto et al., 2020).

In humans, MCT diets have been found to attenuate the effects of the cytotoxicity endured during chemotherapy, reducing intestinal injury and diarrhoea (Wardill et al., 2023). Notably, MCTs increase the level of beneficial bacteria, have a reductive effect on the growth of pathogenic bacteria (Isaacs et al., 1995), and exert an influence in metabolic health due to their capacity to bolster permeability and the intestinal ecosystem as a whole (Rial et al., 2016). As a result, MCT-enriched diets could play a role in the management of metabolic diseases via the modification of gut microbiota and may help promote gut health by bolstering the immune system and reducing oxidative stress and regulating intestinal motility. Other studies have also unearthed the potential for MCTs to contribute to the dietary prevention or amelioration of inflammation (Yu et al., 2019).

On Cardiac Health

Myxomatous mitral valve disease (MMVD) is the most prevalent canine cardiac condition (Keene et al., 2019), and in recent years research has begun to shine light on the incorporation of MCTs as a potential solution. A pivotal 2012 study found a reduction in left atrial (LA) enlargement and blood pressure in six dogs upon receiving a dietary regimen supplemented with a cardiac protection blend (CPB) featuring MCTs (Hall & Jewell, 2012). A subsequent study reinforced the concept that a MCT-enriched CPB enhances metabolism while reducing inflammation and oxidative stress (Li et al., 2019). A comprehensive 2022 review identified key nutrients–with MCTs among them–as potential agents capable of addressing issues such as decreased mitochondrial energy metabolism, reduced ATP availability, heightened oxidative stress, and inflammation, as a result supporting normal cardiac function (Laflamme, 2022). A 6-month dietary intervention trial with MCTs elucidated their remarkable capacity to reduce LA enlargement and slow the progression of early-stage MMVD, identifying them as a source of improved cardiac energetics and mitochondrial metabolism due to their unique transport characteristics (Li et al., 2020), while a more recent study involving dogs suffering from congestive heart failure (HF) demonstrated the significant impact of MCTs on lipid metabolism (Wilshaw et al., 2022). MCT-enriched diets also hold promise for enhancing energy metabolism, particularly in dogs with compromised mitochondrial function. While the specific cardiac diseases studied in humans vary, research has also demonstrated that alterations in the levels of fatty acid composition may serve as indicators of cardiac health in dogs, while also suggesting that via metabolic influence, an MCT-rich diet could offer cardiac protection to dogs with MMVD (Li et al., 2020). In dogs with DMVD experiencing disruptions in energy metabolism, there is a potential avenue for MCT-based intervention given MCTs' suggested influence on mitigating compromised fatty acid oxidation. Furthermore, MCTs' effect on extracellular matrix homeostasis, immune system modulation, glucose regulation, and overall cardiac health in dogs with



The Mixomatous Mitral Valve Disease affects the valve that connects the atrium with the ventricle in the left side of the heart.

DMVD presents an even further-ranging spectrum of possibilities (Li et al., 2015). Despite the aforementioned discoveries, it is crucial to acknowledge the ongoing discourse surrounding the inchoate complexity of metabolic pathways in MMVD. A study earlier this year noted that untargeted metabolic data–while invaluable in generating hypotheses and establishing scope–might not entirely capture the intricacies of the metabolome (Oyama et al., 2023). Further to this, it is worth noting that some of the studies in this context have focused solely on single breeds, or incorporated diets containing supplements such as fish oil, making it challenging to discern the precise effects of MCTs in these metabolic alterations. Additionally, in dogs with exocrine pancreatic insufficiency (EPI), diets containing a high MCT content (35% of total fat content) raised levels of serum concentrations of cholesterol and certain fat-soluble vitamins when compared to a low MCT content (16%). However, while raised cholesterol may impact other biological systems, due to differences in canine-human cardiovascular physiology, increases in cholesterol may be of little interest in cardiac health. In addition, a prolonged dietary intervention study found that feeding a specialised diet for 365 days did not result in a significantly different rate of change in left heart size in dogs with subclinical DMVD compared to the control group (Oyama et al., 2023). However, these results should be viewed with scepticism due to flawed methodology (e.g., dietary "holidays", permittance of snacks, large breed and behavioural variability etc.).

Other Effects (Muscle Health, Obesity, Palatability and Other Factors)

In dogs afflicted with DMVD, MCTs may play a role in safeguarding or improving muscle well-being. This potential benefit arises from the altered expression of genes associated with muscle function (Li et al., 2015). With regards to obesity, MCTs have the potential to enhance cardiac fat utilisation, as indicated by the increased production of citric acid cycle intermediates (crucial for energy metabolism in the heart) and elevated ketogenesis when compared to long chain fatty acids (Li et al., 2020). Other striking research has found that the inclusion of MCTs in dry dog food (up to a level of 11% of metabolisable energy) demonstrated no discernible effects on food acceptance, plasma cholesterol concentrations, protein digestibility, or mineral absorption in healthy adult dogs (Beynen et al., 2002). This implies that incorporating MCTs in dry dog food can be achieved without adversely impacting these key dietary aspects.

Other Species (Cats, Humans and Other Species)

There is a paucity of evidence showing the effect of MCTs in cats, however some interesting findings have emerged. One study found that dietary incorporation of MCTs into feline nutrition exhibited positive outcomes as it did not lead to food rejection, with a minimal influence on lipid metabolism being demonstrated. These findings indicate that diets enriched with MCTs could be beneficial for both healthy cats and those suffering from metabolic disorders. Thus, MCT oils show promise for enhancing feline metabolism and functioning as a valuable food component for cats (Trevizan et al., 2010). However, accord within the scientific community is muddled by contrasting evidence such as that emerging from another study that found that cats were reluctant to consume diets enriched with MCTs. This factor, in turn, makes it uncertain whether this dietary approach would prove efficacious for cats affected with feline cognitive dysfunction syndrome (Gunn-Moore, 2011). While there is a wealth of robust evidence supporting the use of MCT-enriched diets in the management of canine epilepsy, the situation differs for cats. Presently, there is little data on this subject and consequently, no definitive recommendations regarding the use of MCTs in the treatment of feline epilepsy are evident (Volk, 2023). In humans, MCTs have also been noted for their striking effects in epilepsy (Han et al., 2021) and ageing, with dietary MCT supplementation (via oil blends) demonstrating impressive results in improving cognitive performance among patients with Alzheimer's disease (Reger et al., 2004). Additionally, given their potential benefits in cardiac health, MCTs have been proposed for managing cardiovascular diseases, and as further information comes to light, research along this path in canine (and feline) nutrition can also be developed. Delving further, in rodents, MCFAs exhibit notable effects on the composition of the intestinal microbiota and possess inhibitory properties against bacterial concentrations in the digesta, with a particular impact on pathogens like Salmonella and coliforms. Furthermore, several rodent studies have highlighted the potential anti-inflammatory effects of orally administered MCTs in specific contexts (Kono et al., 2003). The CD36 protein is a type of molecule that assists in the digestion and absorption of fats, supports the immune system, and aids in the growth and repair of blood vessels (among other functions). In cases of its deficiency, the supplementation of MCT diets has been shown to confer substantial benefits to cardiac health. This therapeutic intervention has the potential to ameliorate cardiac remodelling, particularly in the context of hypertension. Among spontaneously hypertensive rats, a study also demonstrated that a diet supplemented with MCTs can effectively prevent progressive cardiac remodelling. This effect is attributed to the maintenance of myocardial energy levels and a reduction in oxidative stress (Saifudeen et al., 2017). Such findings not only show potential for the management of cardiac diseases in rodents using MCTs but may also hold promise for clinical applications in cats. In a study involving pigs, specific fatty acids (including short chain and MCFAs, along with long chain polyunsaturated fatty acids) have emerged as potential therapeutic agents in addressing intestinal inflammation. These investigations have unveiled the trophic and cytoprotective effects of fatty acids on intestinal integrity in pigs, indicating a promising path to enhance porcine health and improve nutrient utilisation in human food production (Liu, 2015). However, due to genetic distance any application of this in canine and feline nutrition appears tenuous.

Conclusions

While still an emerging field of discovery, the benefits of MCTs for dogs are well documented, and the reasons for their inclusion in canine nutrition outweigh those for their exclusion. The most compelling case for the deployment of MCTs in canine diets lies in neural health, with an overwhelming body of evidence backing the role of MCTs in optimising cognitive well-being. Further afield, the positive impact of MCTs on dogs' cardiac health has also been shown, however further study is needed to further crystallise these benefits. MCT-enriched diets also show promise in gastrointestinal health, although this area also needs further exploration. While most of the inquiry conducted on MCTs is found in humans and rodents, the evolving body of canine research promises better pet health and further advancements in veterinary medicine and nutrition, as well as a deeper understanding of the mammalian microbiome. Such developments offer prolonged and improved quality of life for dogs, while in turn potentially leading to a reduction in associated healthcare costs for owners. In a nutshell, the ongoing investigation into MCTs in canine health presents exciting prospects for enhancing cardiac, neural, and gastrointestinal well-being, benefiting both pets and their owners.

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