

L-CARNITINE

Vital for the Health and Well Being of People and Pets Around the World

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L-Carnitine was first discovered in 1905 and extensive research since then has clearly demonstrated the important role it plays in many critical metabolic processes. The scope of this article is to help communicate the vital role L-Carnitine plays in supporting the health and well-being of companion animals and to illustrate the similarity in response to applications in the human nutrition sector.

WHAT IS L-CARNITINE

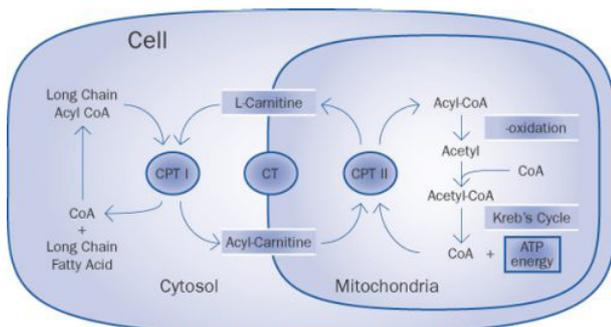
It is understood and confirmed that L-Carnitine is involved in many biochemical reactions and pathways. The reason for the "L" is simply because some synthetic production processes result in two different forms, the "L" and "D" form. L-Carnitine is the only form found in nature and the only form that is biologically active, whereas D-Carnitine has a negative impact on metabolism. Purity of supplementation therefore becomes essential.

L-Carnitine is well known for the role it plays in energy metabolism.

This important role has been confirmed in various species (mammals, avian, aquaculture, etc) at universities and research centres round the world. To understand L-Carnitine and its role in energy metabolism first requires a general understanding of where and how energy is produced. The first point to recognise is that tissues are made of cells and that all cells require an engine (i.e., mitochondria) to produce energy and stay alive. Fatty acids are the densest form of energy utilized to fuel the engine of the cell. Fats are made up of varying degrees of short, medium and long chain fatty acids. L-Carnitine is the "transporter" of all long chain fatty acids across the mitochondria membrane so they can be oxidized and converted into usable energy. Without L-Carnitine or with insufficient amounts of it, these fatty acids would not be properly utilized. Deficiency symptoms of L-Carnitine



Figure 1. Pathway illustrating the role of L-Carnitine in transporting fatty acids into the mitochondria for conversion into energy



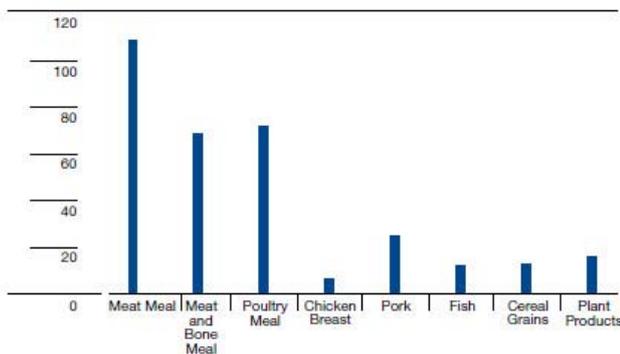
can include muscle necrosis, lipid-storage regulation, hypoglycemia, fatty livers, fatigue and cardiomyopathy. Other established metabolic functions for L-Carnitine include assisting carbohydrate and protein utilization, and "shuttling" of organic acids out of the mitochondria which helps to preserve cell function.

WHERE DOES L-CARNITINE COME FROM

L-Carnitine is excreted via the urine and therefore it requires continual replenishing. There are three main ways to replenish the L-Carnitine

stores in the body: endogenous biosynthesis (made in body); supplementation from the foods we and our pets eat; and via direct supplementation. Endogenous production is complex and requires essential substrates such as the amino acid lysine and methionine. Only protein bound lysine can be utilized and this comes from muscle turnover. In addition, Vitamin C, B3 (ie. Niacin), B6 and iron are required for the synthesis of L-Carnitine to proceed normally. It is important to note that since L-Carnitine is predominantly manufactured by the liver and kidney, any cellular damage or even the aging process of these organs will greatly reduce their ability to produce L-Carnitine. Consequently, supplementation becomes critically important to meet the body's daily L-Carnitine requirements.

Figure 2: L-Carnitine Content (mg/kg) in various food products



L-Carnitine can be found in ingredients commonly included in pet food formulations, however, the concentration of L-Carnitine will differ. The concentration of L-Carnitine is highest in ingredients originating from meat and poultry, but since these ingredients vary in the amount of fat, bone, mineral and water content so too will the final L-Carnitine concentration vary (Figure 2).

A standard rule of thumb is that the redder the meat, the higher the L-Carnitine content. Fruits, nuts, grains, and vegetables contain only trace amounts of L-Carnitine. Because of the inherent variability of L-Carnitine in different ingredients and the fact that many pet food formulations contain plant-based ingredients and other ingredients that contribute only trace amounts of L-Carnitine to the entire formulation, supplementing all formulas with an L-Carnitine safety margin is recommended. As a general recommendation, formulations that are predominantly made up of meat based ingredients should contain an additional 50 to 100 ppm of L-Carnitine and diets formulated with predominantly plant-derived ingredients should supplement L-Carnitine at much higher levels, 100 to 175 ppm.

COMPANION ANIMAL AND HUMAN BENEFITS FROM L-CARNITINE

The metabolic pathway of fatty acid oxidation in conjunction with L-Carnitine is identical to that of humans, laboratory animals, dogs and cats. Therefore, it should not be a surprise that other L-Carnitine metabolic functions outside of fat utilization would also be similar among different species. Thus one can accept the responses



observed from laboratory animal studies to apply also to humans, dogs and cats.

Weight Management

Normally excess body weight occurs when the intake of calories exceeds that which is used for daily metabolic maintenance and exercise. The UK government statistics show that 60% of the UK population is considered to be overweight or obese. According to the US Center and Disease Control (CDC) 27% of the adult population are obese while two-thirds are overweight. In turn, pet obesity is also on the rise. Pet Food Manufacturers' Association research estimates 8 out of 10 pet owners believe that their pet is just the right weight, although when asked which of a series of pictures most closely resembled their pet, only 33% of dog and 23% cat owners were able to choose a "normal" weight picture. According to the Association for Pet Obesity Prevention (APOPP), a recent study conducted in October 2009 concluded that 45% of dogs and 58% of cats are either overweight or obese. The study also found that from 2007 to 2009, the number of overweight dogs and cats had increased by 2% and 5%, respectively. In addition, as our pets continue to live longer lives, the challenges associated with overweight conditions will increase and lead to more health problems.

There are numerous studies that have been conducted which have clearly defined the value of L-Carnitine in weight management programs in humans and pets. A study performed in 100 obese people provided convincing data about the beneficial effects of L-Carnitine in conjunction with dieting and moderate exercise. Obese people had a 25% greater loss in body weight if they supplemented their diet with L-Carnitine and their BMI dropped by 1.5 units (Figure 3), indicating that they were coming closer to their ideal body weight.

Figure 3. One hundred obese humans on a weight reducing regimen with or without supplemental L-Carnitine (3 g/day for 4 weeks)

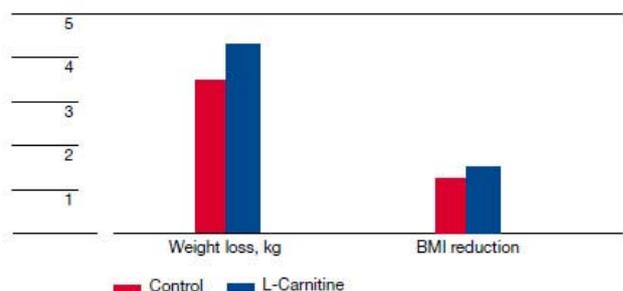


Figure 4. Daily change in lean and fat mass of obese (>30% body fat) dogs offered a weight reducing diet for 12 weeks with or without Carniking

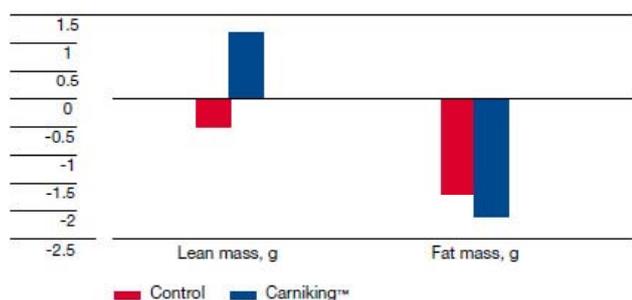
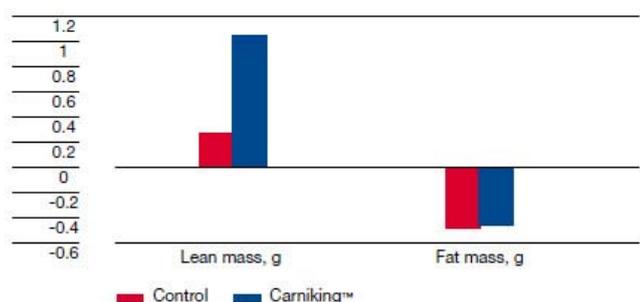
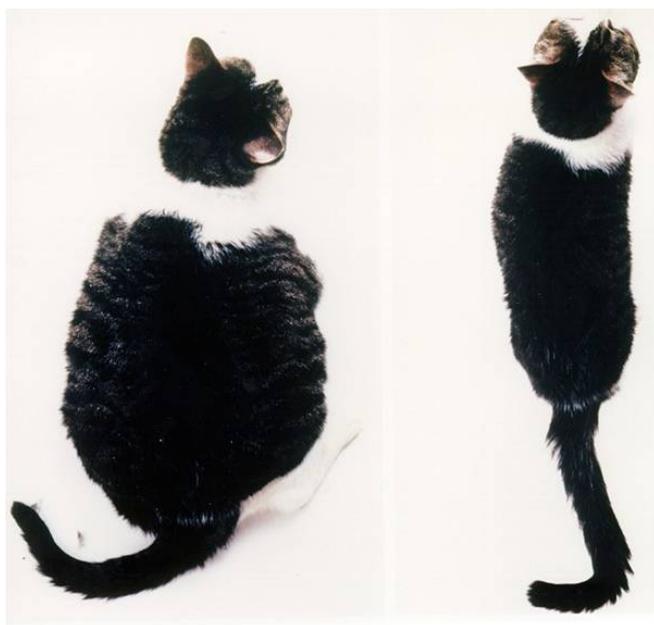


Figure 5. Daily change in lean and fat mass of obese prone cats offered a weight reducing diet for 6 months with or without Carniking



There is substantial evidence from animal studies showing the beneficial effects of supplementary L-Carnitine in weight management and especially its ability to preserve and increase lean body mass during a “diet” feeding regimen. Although the magnitudes of responses are different, the trends and direction is similar for both dogs and cats (Figure 4 and 5, respectively).

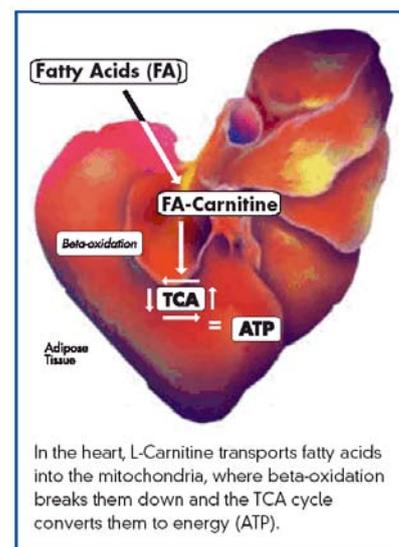


Above: There is substantial evidence from animal studies showing the beneficial effects of supplementary L-Carnitine in weight management

Cardiovascular Health

The heart is a working muscle continuously requiring energy and other nutrients. While the human heart on average beats 72 beats per minute (bpm), a dog’s heart beats at approximately 120 bpm while that of a cat is approximately 180 bpm. As a result, nutrient demands for that of a dog or cat can be expected to be much higher than that of humans. Interestingly, the heart relies mostly (over 70%) on fatty acids and consequently L-Carnitine to help meet its energy needs. It should be to no surprise then that the concentration of L-Carnitine is greater in the heart when compared to all other body organs.

Clinical data indicates that L-Carnitine supplementation can lead to a healthier heart muscle and improved viability. Veterinarians have known for some time that L-carnitine deficiency is associated with dilated cardiomyopathy (known as DCM) in certain breeds of dogs and that it can be used as a treatment. Such deficiencies can be caused by defective uptake or retention by tissues, excessive renal excretion and/or poor biosynthesis. All of these reasons, together with inadequate dietary intake, create situations where supplementation with L-carnitine is necessary.



Healthy Aging and Cognitive Function

Advances to health and nutrition have led to increasing life expectancies – not only for people, but for pets as well. The American Veterinary Medical Association in 2007 reported that the US dog and cat population that is 6 years old and older had increased 44% since 1996. Sales of senior pet products in Japan have risen 10 fold since 2001.

There are a number of theories proposed to explain the aging process and many of them focus on the body’s inability to control free radicals and/or the loss of mitochondrial efficiency. Free radicals can create widespread damage as they attack cell membranes and reduce cell integrity. Typically the body’s line of defence is to quench them with free radical scavengers such as glutathione, Vitamin C, E, and even L-Carnitine. Clinical trials in laboratory rats have found reductions of lipid peroxidation of brain tissue when both young and senior rats are given L-Carnitine supplementation. Clinical trials with rats and dogs have proven valuable in helping to improve cognitive function. In the case of rats, time for both young and aged rats to successfully navigate through a labyrinth was

Table 1: Add Carniking™ to supply the following recommended levels of L-Carnitine to allow for differences in basal diet and breeds

<i>Indication</i>	<i>L-carnitine content in dry food for dogs (mg / kg)</i>	<i>L-carnitine content in dry food for cats (mg / kg)</i>	<i>L-carnitine addition per kg body weight and day (mg/ kg)</i>
Adult	50-100	150-200	5
Aged	150-200	350-400	10
Puppies/kittens	100-150	200-250	10
Gestation	150-200	200-250	10
Lactation	80-100	100-150	10
Illness/ recovery	300-500	500	20
Weight management	300-500	500	20
Cardiomyopathies	500-1000		50-100

<i>Racing/ working dogs:</i>	<i>L-carnitine content in dry food (mg / kg)</i>	<i>L-carnitine addition per kg body weight and day (mg/ kg)</i>
Light work	100-300	10
Moderate work	300-500	20
Heavy work	500-1000	50

improved when L-Carnitine supplementation was provided. In the case of dogs, L-Carnitine has been found to improve the learning process by significantly improving the discrimination and spatial learning of aged dogs.

Infant Nutrition

L-Carnitine synthesis in the newborn is less efficient than in the adult and insufficient to meet normal metabolic requirements. The final step to manufacture L-Carnitine is age dependent. The final step requires hepatic activity of gamma-butyrobetaine hydroxylase and in human infants activity is only at about 10% of that from adults. By 2.5 years of age the activity is still only at 30% of the normal adult and it is not until age 15 that production is considered within the range of a normal adult.

Numerous studies have shown that hypothermia in growing newborns and adequate body temperature is critical for survival. Brown adipose tissue plays an important role in heat production for all infant mammals. The rate at which fatty acids are oxidized by mitochondria from brown adipose tissue for heat production is almost entirely dependent on the presence of L-Carnitine. Therefore, L-Carnitine plays an important role in “non-shivering” thermogenesis in young mammals.

Human infants, puppies and kittens rely heavily on fat as a



source of energy. And because they have a small storage capacity for L-Carnitine and a relatively undeveloped capacity to synthesize L-Carnitine in the body, L-Carnitine should be supplemented for optimal energy metabolism in infants, puppies, and kittens.

New and Novel Science Opportunities

Additionally, researchers are demonstrating the importance L-Carnitine plays in regulating hypoxic stress of cells following exercise. In this role, research shows that supplemental L-Carnitine helps protect the endothelial cells from L-Carnitine deficiency, reduces tissue damage and muscle soreness, and facilitates the overall process of recovery.

SUMMARY

It has been widely understood that L-Carnitine is important for energy metabolism especially associated with fats. New science has helped us to understand the importance L-Carnitine also plays in supporting various other body functions. Today, with the research investments made by companies such as **Lonza** and **Lohmann Animal Health**, we have been able to significantly contribute to the science and application for helping people and their pets live longer, healthier lives.

We would like to encourage you to evaluate the human and pet benefits of L-Carnitine which come as **Carnipure™** and **Carniking™**, respectively. Both **Carnipure™** and **Carniking™** are manufactured by **Lonza**, the global leader of both human and companion animal grade L-Carnitine. For a free sample of Vitamin C+LC effervescent tablets, please contact David Beaumont by e-mail: david.beaumont@lohmann.de



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References are available from the author.