

The Ultimate Guide to Acetyl L-Carnitine

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If vitality and boundless energy are top of your wish list, then acetyl-L-carnitine is a supplement you might want to pop into your shopping basket. This nutrient has a surprising number of cellular interactions, many of which are involved with the way a cell produces energy.

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Introduction

Acetyl-L-carnitine is a substance that's natural to the body, essential for life and readily formed within cells found in the brain, liver, testes and kidneys. Interestingly, cells found in the heart and skeletal muscles have been shown to have the highest concentrations of carnitine, yet these energy hungry tissues are unable to form their own cellular carnitine and must acquire a supply from the bloodstream.

If you eat plenty of meat then it is likely that you'll gain more than enough carnitine from your diet, which accounts for around 75% of your daily requirements. Even though vegans and vegetarians have the capacity to produce their own carnitine within the body, they may be more susceptible to a deficiency.



What is acetyl-L-carnitine?

Acetyl-L-carnitine is a derivative of the amino acid carnitine, which is also the generic name for the three forms of carnitine found in nutritional supplements:

- **L-carnitine**
- **propionyl-L-carnitine**
- **acetyl-L-carnitine**

Although carnitine is an amino acid, it has a similar structure to a B vitamin called choline and, like many of the B vitamins, is involved in transforming food into energy. Each different form of carnitine plays a key role in releasing energy from fat but they each also have an affinity for different tissues and cells in the body, which enables them to support specific areas of health.

Carnitine not sourced from food is produced by cells from two essential amino acids – lysine and methionine – as well as a good supply of vitamins C, B3 and B6 and iron. These extra nutrients are helpful cofactors for the two enzymes which produce carnitine.^{1,2,3} Depleted levels of these cofactors could potentially lead to a carnitine deficiency, which may result in inefficient cellular energy production.

L-carnitine is primarily made in the liver and then carried by the bloodstream to skeletal and heart muscle, which rely on L-carnitine for converting fatty acids into energy. The body can convert L-carnitine to acetyl-L-carnitine and vice versa depending on the metabolic needs of the cells. Under certain conditions, the body's demand for L-carnitine may exceed an individual's ability to produce adequate levels, for these individuals carnitine becomes a conditionally essential nutrient.

The difference between acetyl-L-carnitine and L-carnitine

Acetyl-L-carnitine tends to be far more easily absorbed in the gut, so the acetyl form is considered a superior version compared to standard non-acetylated forms. The acetyl group helps carnitine become more soluble in water, accelerating its uptake into cells and allowing it to pass more easily into the mitochondria and cross the blood-brain barrier. This means the acetyl form has more interactions with the central nervous system.

Although the structural differences between L-carnitine and acetyl-L-carnitine are small, the biochemical differences and effects on metabolism are considerable. Although L-carnitine has mainly been used in studies, research has determined that acetyl-L-carnitine is better absorbed and has greater activity within the cells.⁴

The important roles of acetyl-L-carnitine

Acetyl-L-carnitine is involved in both the growth and breakdown of substances in cellular metabolism. It is a well-absorbed nutrient containing equal parts of carnitine and acetyl, both of which possess neurobiological properties.⁵

The carnitine shuttle

Carnitine very efficiently ferries long chain fatty acids into the mitochondria where a series of chemical reactions turn these fats into energy. This is known as the carnitine shuttle. The acetyl part enables acetyl-L-carnitine to be active in the brain and nerve fibres. The acetyl part is also utilised in the production of acetyl coenzyme A (CoA) an important molecule involved with cellular metabolism which also helps produce a neurotransmitter called acetylcholine.⁶

Fat, carbohydrate and protein metabolism

Carnitine participates in fat metabolism within the mitochondria which influences all other metabolism within the cells including insulin and carbohydrate burning. The enzymes that metabolise fat are in constant chemical communication with the enzymes that metabolise glucose. Carnitine also transports metabolic fragments and residues known as acyl groups formed during the metabolism of amino acids (proteins) out of the mitochondria to prevent a toxic accumulation. A build-up of acyl groups which attach to acetyl CoA have been linked to the development of insulin resistance.⁷ If acyl group accumulation occurs in organs such as the heart then this may lead to inflammation.⁸

1. How does acetyl-L-carnitine affect mitochondrial function?

The mitochondria are the energy factories within cells and their main purpose is to generate energy which is used to fuel all biochemical and physiological processes. The mitochondria also perform other important tasks including:

- **Regulating the innate immune system**⁹
- **Regulating cell growth**⁹
- **Signalling between cells**⁹
- **Producing and consuming free radicals**¹⁰
- **Programming cell death**¹⁰
- **Ion balance**¹⁰
- **Calcium storage**¹⁰

Carnitine is of critical importance in maintaining normal mitochondrial function, not only because of its role in transporting fatty acids into the mitochondria but also because it removes acyl groups from the mitochondria that would otherwise build up and potentially lead to mitochondrial dysfunction, cell death or enhanced generation of free radicals.

Many of the health benefits related to acetyl-L-carnitine are linked to its role in energy metabolism although some research suggests acetyl-L-carnitine may also exert positive effects on brain function in terms of supporting neuronal metabolism and helping neutralise oxidative stress.¹¹

2. Could acetyl-L-carnitine help support weight management?

Weight gain and obesity are prime culprits for poor health in the long term. Maintaining a healthy weight by following a well-balanced diet, exercising daily and making other positive lifestyle choices is important for general health and wellbeing. However, obtaining the perfect balance of nutrients to promote fat metabolism isn't always easy, especially during ill health or if you have dietary restrictions.

Supplementing with acetyl-L-carnitine could provide valuable nutritional support in these instances. Having the additional help of a nutrient that transforms fat into fuel may make weight management seem far less challenging.

3. What's the link between acetyl-L-carnitine and endurance sports?

Marathon runners and athletes are hugely invested in boosting their performance and are likely to have tried a variety of nutritional supplements. The objectives for supporting muscle development, engaging fat burning and clearing the build-up of lactic acid are high in the agenda for most fitness enthusiasts. Acetyl-L-carnitine may fit the bill in some respects, partly because of its ability to transport metabolic waste such as lactic acid out of the cells, but also for its involvement in fat metabolism.

Interestingly, several studies investigating the use of acetyl-L-carnitine for exercise recovery and muscle soreness have reported positive results.¹² It may therefore be possible to help maximise a workout with the addition of acetyl-L-carnitine alongside a healthy balanced diet.

In terms of energy or lack of it, carnitine levels may be altered for individuals suffering from chronic fatigue, which may suggest mitochondrial dysfunction.¹³

4. Could acetyl-L-carnitine be helpful for supporting the heart?

The heart is a unique organ which pumps around five litres of blood per minute, beats about 40 million times a year and requires a tremendous amount of energy over lifetime.¹⁴ It's by far the most metabolically active organ in the body and possesses the highest concentration of mitochondria compared to any other body tissue.¹⁵ Any disruption to mitochondrial function is known to have a significant impact on many conditions, including cardiovascular disorders.¹⁶

Although the mechanisms behind heart irregularities are complex, there are several metabolic abnormalities that could be linked to declining heart function and one of these is mitochondrial dysfunction.¹⁷ A healthy balanced diet contains all the nutrients needed to support mitochondrial function including carnitine. Research suggests the heart is one of the organs most affected by carnitine deficiency.¹⁸ The addition of acetyl-L-carnitine supplementation to a healthy diet may offer valuable nutritional support especially for those with dietary restrictions.



What are the best food sources of acetyl-L-carnitine?

The primary food sources of carnitine include meat and animal products, with red meat, particularly lamb being the richest source. Poultry, milk and dairy products contain lower amounts. Vegetarians avoiding dairy foods and vegans are thought to get very little carnitine from their diets. Small amounts of carnitine are found in plant foods such as tempeh and avocado.

FOOD SOURCES OF CARNITINE	MILLIGRAMS (MG)
BEEF STEAK COOKED 4OZ	56-162
MINCED BEEF COOKED 4OZ	87-99
WHOLE MILK 1 CUP	8
COD COOKED 4 OZ	4-7
CHICKEN BREAST COOKED 4 OZ	3-5
CHEDDAR CHEESE 2 OZ	2
WHOLE-WHEAT BREAD 2 SLICES	0.2
ASPARAGUS COOKED ½ CUP	0.1

Source: ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/

How much acetyl-L-carnitine do you need?

There are currently no government guidelines for a recommended daily amount. However, for those considering supplementing, the Linus Pauling Institute recommends acetyl-L-carnitine 500mg to 1g, daily.¹⁹ On average, adults eating a healthy balanced diet are thought to obtain 60-180mg per day.²⁰ Whereas vegans and vegetarians tend to have considerably lower intakes of around 10-12mg per day.

Cellular levels of acetyl-L-carnitine depend very much on how much you are gaining from your diet and how much your cells are producing. Obtaining adequate amounts of lysine, methionine, and vitamins C, B3 and B6 and iron is also important for carnitine production. However, some of these nutrients may also be a challenge for vegetarians and vegans, especially if care is not taken to include a good balance of a wide range of foods, daily.

People with kidney or liver disease may be at risk of carnitine deficiency. In these instances supplementation is a popular option.



Are there risk factors for acetyl-L-carnitine deficiency?

There are three types of carnitine deficiency:

1. **Primary carnitine deficiency** – occurs due to genetic mutations which affect the carnitine-transporter system within cells.
2. **Secondary carnitine deficiency** – occurs due to liver or kidney disorders.
3. **Abnormal carnitine regulation** – may occur due to ageing or with conditions such as diabetes, malnutrition, cardiomyopathy and sepsis.²¹

Symptoms are most severe for primary carnitine deficiency and they include:

- Low blood sugar (if the liver is affected)
- Swelling or shortness of breath (if the heart is affected)
- Delayed movement (motor development)
- Muscle weakness
- Fatigue
- Irritability

Six quick facts about acetyl-L-carnitine

1. Carnitine was first isolated from meat in 1905.
2. The name carnitine is derived from the Latin word carnis, which means flesh/meat.
3. Carnitine from meat is converted by intestinal bacteria to trimethylamine. High levels of this compound may lead to a 'fishy' body odour.
4. Meat that is a deeper red colour tends to have higher levels of carnitine.
5. Although carnitine is an amino acid, unlike other amino acids it's not used to make proteins.
6. Research has identified that carnitine levels decrease significantly with age.²²

Are there different types of carnitine supplements?

There are various forms of acetyl-L-carnitine supplementation such as tablets, capsules, powders, sprays and liposomal gels, all of which have different absorption rates. Below are the most common:

- **Liposomal acetyl-L-carnitine:** by far the most superior way to take acetyl-L-carnitine as a nutritional supplement. The ingenious formulation of liposomes protects the nutrient and carries it rapidly to the bloodstream and on to the cells, providing maximised absorption.
- **L-carnitine:** is a natural substance involved in energy metabolism. In supplement form standard oral L-carnitine is not well absorbed.
- **Propionyl-L-carnitine:** this form is bound to the amino acid glycine and esterified with a short chain fatty acid. It is converted to L-carnitine and propionyl coenzyme A in the mitochondria. Like other forms of carnitine, it helps the body to produce energy.
- **D-carnitine:** this synthetic form may interfere with the absorption of natural L-carnitine and could hinder mitochondrial fatty acid oxidation and may lead to depletion in cardiac and skeletal muscles.²³

Altrient Acetyl-L-Carnitine does not contain any excipients.

Many lower quality products add unnecessary fillers and excipients to enhance the flavour, add colour, bulk up the product, bind the ingredients together, enhance the flow during processing and preserve the ingredients. These are not necessarily harmful, but some may affect the absorption of carnitine. Check the ingredients list for maltodextrin, sucrose, sweeteners, cellulose, magnesium stearate, carrageenan, stearic acid, silicon dioxide, titanium dioxide and potassium ascorbate.

What exactly are liposomes?

Altrient liposomal supplements stand out from other comparable products because of their unique Liposomal Encapsulation Technology (LET). Liposomes are tiny microscopic bubbles made up of an outer layer of essential phospholipids, which encapsulate the biologically active contents forming a protective membrane. This innovative delivery system offers protection from oxidation and degradation from digestive processes and allows the liposomal contents to be delivered intact to the exact target where the contents can be utilized by the body. Liposomes are able to achieve rapid and superior absorption.

Liposomal Altrient Acetyl-L-Carnitine is manufactured by LivOn labs in the US using unique patented Liposomal Encapsulation Technology (LET). One sachet of Altrient liposomal Acetyl-L-carnitine contains 1000mg of acetyl-L-carnitine plus an extra 500mg of the important phospholipid, phosphatidylcholine.

Why are phospholipids so important?

Phospholipids are naturally occurring fatty substances that help carry out the functions of cell membranes and regulate many biological processes including cell signalling and genetic regulation.²⁴ Phospholipids provide important essential fatty acids which help to inhibit inflammatory pathways in the body and are shown to contribute to the normal function of the heart.²⁴

Phosphatidylcholine is by far the most abundant phospholipid in plasma and is used to make a neurotransmitter called acetylcholine, which functions throughout the central and peripheral nervous system. Phosphatidylcholine is also an important component of the cells that line the colon, which helps act as a first line of defence against bacterial invasion.

Why choose a liposomal form of acetyl-L-carnitine?

The bioavailability of L-carnitine from our food is relatively high, however this can't be said about standard oral forms of L-carnitine supplements where absorption is considerably lower.²⁵ Supplements containing acetyl-L-carnitine are thought to be better absorbed, particularly via liposomal delivery systems such as Altrient Acetyl-L-Carnitine, which bypass the digestive restrictions associated with standard oral supplements. Research shows that liposomes offer more effective site-specific delivery and efficient absorption through cells.^{26,27,28} These unique properties cannot be attributed to other standard forms of carnitine supplements.

Top 5 advantages of Altrient Acetyl-L-Carnitine

1. **Survives digestion** – the microscopic phospholipid bubble surrounding the acetyl-L-carnitine protects it from oxidation and resistance to digestive enzymes, gastric juices, bile salts, alkaline solutions, intestinal bacteria and free radicals produced by the body.
2. **Energy generator** – acetyl-L-carnitine is one of many important cofactors in some of the biological pathways that transform fat into fuel for energy.
3. **Gentle on the stomach** – even at high doses liposomal Altrient Acetyl-L-Carnitine doesn't tend to be associated with any gastrointestinal discomfort.
4. **More efficient absorption** – liposomal Altrient Acetyl-L-Carnitine is produced by LivOn labs which uses cutting edge liposomal encapsulation technology to support maximised absorption.
5. **Reaches the brain** – liposomal Altrient Acetyl-L-Carnitine has the advantage over standard forms of L-carnitine supplements because it seems to be able to cross the blood brain barrier.

How safe is acetyl-L-carnitine?

Overall acetyl-L-carnitine is considered a safe and well-tolerated supplement with rare side effects. Occasionally higher doses of more than 5-6g per day may cause nausea or gastric upset.³⁰ However, this is most likely avoided with a liposomal form of acetyl-L-carnitine supplement.

Supplementation should be avoided during pregnancy or breastfeeding as there is insufficient evidence regarding its safety.

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References

1. Amaya I, Botella M, Fenech M & Valpuesta V. Vitamin C Content in Fruits: Biosynthesis and Regulation. *Front. Plant Sci.* 2019, 9:2006.
2. Flanagan, J.L., Simmons, P.A., Vehige, J. et al. Role of carnitine in disease. *Nutr Metab (Lond)* 7, 30 (2010). <https://doi.org/10.1186/1743-7075-7-30>
3. Johnston, C.S., Corte, C. & Swan, P.D. Marginal vitamin C status is associated with reduced fat oxidation during submaximal exercise in young adults. *Nutr Metab (Lond)* 3, 35 (2006).
4. Mendlesen S (2018). *Metabolic Syndrome and Psychiatric illness. Interactions, Pathophysiology, Assessment and Treatment.* Elsevier: UK.
5. Pettegrew, J., Levine, J. & McClure, R. Acetyl-L-carnitine physical-chemical, metabolic, and therapeutic properties: relevance for its mode of action in Alzheimer's disease and geriatric depression. *Mol Psychiatry* 5, 616–632 (2000).
6. Flanagan, J.L., Simmons, P.A., Vehige, J. et al. Role of carnitine in disease. *Nutr Metab (Lond)* 7, 30 (2010). <https://doi.org/10.1186/1743-7075-7-30>
7. Chen G et al. L-carnitine treatment of insulin resistance: A systematic review and meta-analysis. *Adv Clin Exp Med.* 2017;26(2):333–338
8. Longo N, Frigeni M, Pasquali M. Carnitine transport and fatty acid oxidation. *Biochim Biophys Acta.* 2016;1863(10):2422–2435.
9. Finkel et al. The role of mitochondria in ageing. *J Clin Invest.* 2018;128(9):3662-3670.
10. Fielding R, Riede L, Lugo JP, Bellamine A. l-Carnitine Supplementation in Recovery after Exercise [published correction appears in *Nutrients.* 2018; 26;10(5):]. *Nutrients.* 2018;10(3):349.
11. Acetyl L-l-carnitine monograph. *Alternative medicine review* 2010; 15,1: 76-83 <http://archive.foundationalmedicinereview.com/publications/15/1/76.pdf>
12. Fielding R, Riede L, Lugo JP, Bellamine A. l-Carnitine Supplementation in Recovery after Exercise [published correction appears in *Nutrients.* 2018; 26;10(5):]. *Nutrients.* 2018;10(3):349.
13. Flanagan, J.L., Simmons, P.A., Vehige, J. et al. Role of carnitine in disease. *Nutr Metab (Lond)* 7, 30 (2010). <https://doi.org/10.1186/1743-7075-7-30>
14. Mendlesen S (2018). *Metabolic Syndrome and Psychiatric illness. Interactions, Pathophysiology, Assessment and Treatment.* Elsevier: UK.
15. Brown, D., Perry, J., Allen, M. et al. Mitochondrial function as a therapeutic target in heart failure. *Nat Rev Cardiol* 2017; 14,238–250 .
16. Flanagan, J.L., Simmons, P.A., Vehige, J. et al. Role of carnitine in disease. *Nutr Metab (Lond)* 7, 30 (2010). <https://doi.org/10.1186/1743-7075-7-30>
17. Marcovina SM, Sirtori C, Peracino A, et al. Translating the basic knowledge of mitochondrial functions to metabolic therapy: role of L-carnitine. *Transl Res.* 2013;161(2):73–84.
18. Flanagan, J.L., Simmons, P.A., Vehige, J. et al. Role of carnitine in disease. *Nutr Metab (Lond)* 7, 30 (2010). <https://doi.org/10.1186/1743-7075-7-30>
19. Oregon State University. Linus Pauling Institute. L-Carnitine. <https://lpi.oregonstate.edu/mic/dietary-factors/L-carnitine>. [Accessed 5.3.20]
20. NIH. CARNITINE – Health Professional Fact Sheet. [ods.od.nih.gov>factsheets>Carnitine-HealthProfessional](https://ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/). [Accessed 21.2.20.]
21. Brand MD, Orr AL, Perevoshchikova IV, Quinlan CL. The role of mitochondrial function and cellular bioenergetics in ageing and disease. *Br J Dermatol.* 2013;169 Suppl 2(0 2):1–8.
22. Mendlesen S (2018). *Metabolic Syndrome and Psychiatric illness. Interactions, Pathophysiology, Assessment and Treatment.* Elsevier: UK.
23. Preedy VR & Watson RR (2019). *Reviews in Food and Nutrition Toxicity, Volume 2, 1st Edition.* CRC Press: UK
24. Harvard T.H.Chan. The Nutrition Source. Omega-3 Fatty Acids: An Essential Contribution. <https://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/fats-and-cholesterol/types-of-fat/omega-3-fats/> [Accessed 11.3.20.]
25. Oregon State University. Linus Pauling Institute. L-Carnitine. <https://lpi.oregonstate.edu/mic/dietary-factors/L-carnitine>. [Accessed 5.3.20]
26. Acosta E. Bioavailability of nanoparticles in nutrient and nutraceutical delivery. *Current opinion in Colloid & Interface Science* 2009; 14, 1:3-15.
27. Amaya I, Botella M, Fenech M & Valpuesta V. Vitamin C Content in Fruits:
28. Basnet P, Hussein H, Tho I., et al. Liposomal delivery system enhances anti-inflammatory properties of curcumin. *Journal Pharmaceutical Science* 2012. 101;2:598-609.
29. Choonara YE, Modi G, Mufamadi et al. A Review on Composite Liposomal Technologies for Specialized Drug Delivery. *Journal of Drug Delivery* 2010.2011: 1-19
30. NIH. CARNITINE – Health Professional Fact Sheet. ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/ . [Accessed 21.2.20.]
31. The Physics Factbook. Power of a human heart. <https://hypertextbook.com/facts/2003/IradaMuslumova.shtml> [Accessed 9.3.20]

Additional bibliography

Boengler K, Kosiol M, Mayr M, Schulz R, Rohrbach S. Mitochondria and ageing: role in heart, skeletal muscle and adipose tissue. *J Cachexia Sarcopenia Muscle.* 2017;8(3):349–369.

NFH Nutritional Fundamentals for Health 2017. Acetylcarnitine SAP. <https://nfh.ca/wp-content/uploads/2019/07/Acetylcarnitine-SAP.pdf> [Accessed 6.3.20]



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