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ABSTRACT

Leucine is an aliphatic, non-polar amino acid, its chemical structure includes a carboxylic and α -amino acid and a unique side chain. It is mainly metabolized in muscular tissue rather than the liver, and this imparts its role in energy production and muscle protein synthesis. Leucine is a dietary amino acid which is oftenly referred as a key amino acid for growth of muscle due to its involvement in initiating MPS (muscle protein synthesis). It possesses the efficiency to directly stimulate the myofibrillar muscle protein synthesis. This effect is the outcomes of its role as a trigger of the mechanistic target of rapamycin (mTOR), a serine-threonine protein kinase which regulates protein biosynthesis and cell growth. The activation of mTOR by leucine is arbitrated through Rag GTPases, leucine binding to leucyl-tRNA synthetase, leucine binding to sestrin2, and possibly other mechanisms.

Leucine performs a numerous function in the body. It helps to produces growth hormone and regulate blood sugar, improves wound healing, but it is commonly known for its function in muscle growth system. Building of Muscle, Regaining of Muscle, Prevention of Muscular Loss, Muscular recovery and preservation, Muscular protein synthesis, developing muscular strength are some its beneficial effects in building muscular health.

Because of its beneficial effect in muscular growth athletes should consume in their diet. But researches studies confirm that Muscular Protein synthesis not only occur by leucine only, but the researches says that MPS activates if leucine combines with the resistance training like weight lifting and other body weight exercises supplemented with other essential amino acids.

Keywords: chemical structure, protein synthesis, leucine, growth hormone, muscular strength etc.

INTRODUCTION

Leucine is a Greek word which means "white" because of its common appearance as a white powder. It is encoded by UUA, UUG, CUU, CUC, CUA, and CUG codons. It is one of among nine essential amino acids. Like isoleucine and valine, leucine is a branched-chain amino acid.

Structure of Leucine

Leucine, is an amino acid obtained by the hydrolysis of some very common proteins. The

Chemical Formula of Leucine - C₆H₁₁NO₂

Molecular weight of Leucine - 131.17 g/mol.

Leucine is a aliphatic, non-polar amino acid, its chemical structure includes an carboxylic and α amino acid and a unique side chain. This side chain is of an isobutyl group, which differentiates leucine from other amino acids [1]. This branched side chain occurrence in leucine permit it to be metabolized in a different way comparing to other amino acids. It is mainly metabolized in muscular tissue rather than the liver, and this imparts its role in energy production and muscle protein synthesis [2]. Its chemical structure is:



The Biological Role of Leucine

When dietary protein is consumed, it is broken down into its constituent amino acids. The chief end products of leucine metabolism are acetyl-CoA and acetoacetate thus, among two ,it is one of the exclusive ketogenic amino acids, while lysine amino acid is being the other [3-4]. Leucine is one of the three branched chain amino acids BCAAs, along with isoleucine and valine. Leucine is a dietary amino acid which is oftenly referred as a key amino acid for growth of muscle due to its involvement in initiating MPS (muscle protein synthesis). It possess the efficiency to directly stimulate the myofibrillar muscle protein synthesis. This effect is the outcomes of its role as a trigger of the mechanistic of target rapamycin (mTOR), a serine-threonine protein kinase which regulates protein biosynthesis and cell growth. The activation of mTOR by leucine is arbitrated through Rag GTPases, leucine binding to leucyltRNA synthetase, leucine binding to sestrin2, and possibly other mechanisms [5-6].

Mechanistic target of rapamycin (mTOR) -Leucine and β -hydroxy β -methyl butyric acid, are minor product of metabolism of leucine, retains pharmacological achievement in human beings and verified boost protein been to biosynthesis through phosphorylation of the mechanistic of rapamycin (mTOR). target Rapamycin, which is also known as Sirolimus, which is a macrolide compound, is used to cover coronary stents, prevents rejection of organ transplant, treatment of disease rare lung called lymphangioleiomyomatosis, and treat perivascular epithelioid cell tumour (PEComa) [7]. It has immunosuppressive functions in humans and is particularly beneficial in preventing the kidney transplants rejection. It is a mammalian target of rapamycin (mTOR) kinase inhibitor that reduces the sensitivity of T cells and B cells to interleukin-2 (IL-2), inhibiting their activity [8].



Fig. 1. Leucine goes into the cells to encourage mTORC1 signalling: through amino acid transporters as well as glutamine (Gln). Leucine enters the cell to stimulate mTORC1, which is a principal regulator for metabolism and cell growth [8].



Fig. 2. leucine encourages mTOR signal to ribosomal protein S6 kinase enzyme for MSP

Among all amino acids, leucine has a powerful signalling effect, specifically stimulating the mTOR (mammalian target of rapamycin) pathway which is a crucial regulator of muscular repair and cellular growth. This pathway is responsible for increasing protein synthesis, particularly in skeletal muscles, which leads to hypertrophy over time.

Moreover, leucine helps to prevent muscle protein breakdown, further supporting muscle maintenance, particularly in older adults or individuals recovering from injury. Research shows that increased leucine intake, either through dietary sources or supplementation, can improve muscle mass gains, especially when combined with resistance exercise [9-10].

Importance of leucine in muscular strength

Human dietary sources of leucine are foods that holds protein like dairy products, meats, beans and other legumes and soy products as well. Leucine performs a numerous function in the body. It helps to produces growth hormone and regulate blood sugar, improves wound healing, but it is commonly known for its function in muscle growth system [11]. Some of its functions are as follows:

1. Building of Muscle

Leucine is known vital for muscular building and repair. According to the National Institutes of Health (NIH), BCAA supplements don't seems like to increase strength but it may upsurge muscle mass when associated with strength training.

2. Regaining of Muscle

Leucine helps muscles to recover fast after vigorous use of muscle. In one of the study of extremely fit cyclists, taking leucine after a cycling improved their performance to the next day. They also reported for overall less tiredness.

3. Prevention of Muscular Loss

Leucine has been confirmed to progress strength in elderly, especially those with sarcopenia (muscular loss). Sometimes exercise also enhance the benefit of prevention of muscle loss. In one of the research, it was found that an adult men increased their protein synthesis even though they were not having its deficiency.

4. Muscular recovery and preservation

Leucine has been shown to help in muscular recovery and preservation, specifically in situations of extended physical pressure or stress or muscle wasting. Its role in dropping off muscle degradation and encouraging protein synthesis aids in quicker recovery and maintenance of muscle mass.

5. Muscular protein synthesis: Leucine is a main regulator of muscular protein synthesis. It stimulates the mechanistic target of rapamycin (mTOR) signalling pathway, that plays a essential role in the regulation of cellular growth and metabolism. This activation increases the protein synthesis and muscle growth, and so defining leucine as an significant nutrient for athletes and individuals involved in resistance training.

6. Developing muscular strength

In a study conducted at the University of Leeds, subjects who consumed 4 gram of Lleucine supplementation increased their 5-rep max strength on 8 exercises by 40.8%. This was a 32% improvement in strength over the placebo group, athletes can ensure they are providing their bodies with adequate **L-Leucine** to support **leucine muscle protein synthesis** and achieve optimal results in muscle development.

Importance of leucine other than muscular system

1. Management of Weight

Leucine plays very important role in weight management. In studies on animal, it was found that the supplementation of leucine increases the response to leptin hormone (a hormone that regulates hunger). Some researchers also believes that the success of high-protein diets may be due in part to the role of leucine in regulating blood glucose.

2. Metabolic health

Developing research of nowdays proposes that it have helpful and constructive effect on metabolic health out there its role in metabolism of muscle and energy. Studies have shown that supplementation of leucine can also effect metabolism of fat, which leads to reduced body fat and healthier body composition. This effect is attributed to leucine's ability to modulate metabolic pathways and enhance glucose oxidation.

Leucine helps regulate blood sugar levels and insulin sensitivity, supporting a healthy metabolism. It can also enhance fat loss by preserving lean muscle tissue, contributing to a more efficient metabolic rate.

3. Hormonal regulation

Leucine effects the production of numerous hormones, including human growth hormone (HGH) and insulin. By moderating insulin levels, leucine contributes to better glucose metabolism and may contribute in management of blood glucose levels. Its impact on HGH production further supports muscle growth and repair.

4. Energy production

In addition to its role in protein synthesis, leucine subsidizes its role in production of energy. It is metabolized into Acetyl-CoA and acetoacetate, which are involved in the production of ATP (adenosine triphosphate), the primary energy currency of the cell.

5. Supports immune function

A healthy immune system is something everyone can benefit from, and leucine plays a role. By helping produce antibodies and other immune cells, the nutrient can aid the body in defending against infections and illness.

Optimal Leucine Intake for Muscle Growth

To maximize MPS, research suggests consuming approximately 2-3 grams of leucine per meal. This amount seems to "trigger" the mTOR pathway, optimizing the anabolic response. The actual leucine content of various protein sources varies, with whey protein standing out as one of the richest sources [12-13]. For example, whey protein contains approximately 10 grams of leucine per 100 grams, compared to soy protein, which offers about 6 grams of leucine for the same amount.

Older individuals, in particular, may benefit from even higher leucine consumption. Age-related declines in muscle mass, known as sarcopenia, often necessitate greater protein and leucine intake to maintain muscle function. Studies show that elderly populations may need up to 40 grams of protein per meal, including a higher proportion of leucine, to stimulate MPS effectively [14-15].

Leucine and Resistance Training

Effect of Leucine on muscular growth is very effective when associated with resistant strength training. Body weight exercises or weightlifting or generate microtears in these muscle fibers, that the body then maintenances through muscle protein synthesis (MPS), assisted by amino acids. In postworkout eating leucine-rich protein food aids the body to rebuild these fibers more competently, that sometimes leads to muscular hypertrophy over the time.

For fitness enthusiasts and athletes, timings of leucine intake around and during the training period can promote muscle repair and improve recovery [16-20]. MPS (Muscular Protein Synthesis) can activates if consuming leucine only, researches illustrates that combines leucine with other essential amino acids, particularly in the form of complete proteins, results in a more sustained anabolic response.

The Leucine Threshold and Protein Quality

Not all proteins are created equal. The quality of a protein source is often measured by its digestibility and amino acid profile, with leucine content being a critical factor for muscle growth. The term "leucine threshold" refers to the minimum amount of leucine needed to initiate muscle protein synthesis. Highquality proteins, such as whey, egg not only contain sufficient leucine to meet this threshold but also provide all the other essential amino acids required for optimal muscle growth.

Foods with Leucine

There are many dietary sources for leucine and other BCAAs. Consider these healthy sources of amino acids:

- Chicken breast: Chicken breast provides about 2.6 grams of leucine per 100 grams. It's an excellent source of high-quality protein, supporting muscle repair and growth.
- 2. **Eggs:** One large egg contains approximately 0.5 grams of leucine. Eggs are rich in protein and essential amino acids, making them a perfect addition to any muscle-building diet.
- 3. **Tuna:** A 100-gram serving of tuna provides about 1.7 grams of leucine. Tuna is a lean source of protein that helps promote muscle recovery.
- Soybeans: One cup of cooked soybeans contains 2.8 grams of leucine. They are a plant-based source of leucine, ideal for vegetarians and vegans.
- Whey protein: A typical serving of whey protein powder offers about 2.5–3 grams of leucine. It's a convenient supplement for promoting muscle growth and recovery.
- 6. **Beef:** A 100-gram serving of beef provides about 2.1 grams of leucine. Rich in protein, it supports muscle strength and repair.
- Greek yogurt: One cup of Greek yogurt has around 1.3 grams of leucine. It's a great dairy option packed with protein and probiotics for digestive health.
- Lentils: A cup of cooked lentils offers about 1.3 grams of leucine. They're a great plantbased protein source for muscle repair and overall nutrition.
- Peanuts: One ounce of peanuts contains around 0.6 grams of leucine. They are a snackable, nutrient-dense option rich in healthy fats and protein.
- 10. Cottage cheese: One cup of cottage cheese contains about 1.5 grams of leucine. It's a

high-protein dairy product that helps support muscle recovery after exercise.

11. **Pumpkin seeds:** One ounce of pumpkin seeds provides about 0.5 grams of leucine. They're a nutrient-packed snack, offering protein and healthy fats for overall wellness.

CONCLUSION

Leucine is a branched chain of great importance in muscular strength with other beneficial effects in body. Animal sources are the best source for leucine but plant sources of protein also possess little bit amount of leucine. Leucine

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