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THE ABSORPTION OF AMINO ACIDS IN THE DIGESTIVE TRACT AND ITS MOVEMENT FROM DIGESTIVE TRACT TO SYSTEMIC CIRCULATION

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Introduction

It has been reported that absorbed dietary proteins in the human body consist of 90% amino acids and 10% peptides (ref 1). Approximately 90~95% of the absorption of digested protein occurs in the small intestine with the remaining 5~10% in the stomach and large intestine (ref 2, 3). However, this percentage can vary greatly depending on the source and amount of protein, amount of transporter proteins, and the amino acid profile/composition in the proteins.

The absorbed amino acids are first utilized by the small intestine and the splanchnic bed, liver included, for their own protein synthesis and oxidation, which has been reported to be 30% to 50% (ref 4). In our survey of published data, the range can be from 10% to 70% (ref 5). The remaining absorbed amino acids enter blood circulation for systemic distribution. The other component of the total amino acid pool in the blood is the tissue production of amino acids. Amino acids released from tissues (endogenous amino acids) come from proteolysis and de novo synthesis (ref 6). For example, in reference 7, a leucine intake of 40 mg/kg/day, approximately 3 g leucine intake for a 70 kg BW person, accounts for only about 30% of plasma leucine (0.98g) where as endogenous leucine contributes to almost 70% of the pool (2.29 g). Less than 1% of the absorbed amino acids/peptides are excreted from the human body (ref 8).

Amino Acid Absorption

Based on scientific papers and physiology text (ref 1, 2), the small intestine is the part of the intestines where 90~95% of digestion and absorption of food occurs with the remaining 5~10% taking place in the stomach and large intestine. However, the actual percentage of absorption varies significantly for individual amino acids depending on:

1. **Protein sources**
   This could be an intact protein, hydrated protein, amino acid mixture, or a single amino acid. Free form amino acids have better absorption rate. Ingestion of a protein hydrolysate, as opposed to its intact protein, accelerates protein digestion and absorption from the gut (ref 9), augments postprandial amino acid availability, and tends to increase the incorporation rate of dietary amino acids into skeletal muscle protein.

2. **Transporter system**
   There are many transport systems that are responsible for the absorption of one amino acid. One transport system can drive many amino acids into intestinal cells, such as the leucine transporters that can transport all neutral amino acids, although with a high affinity for leucine (meaning leucine has the priority). In an amino acid mixture with leucine, the presence of leucine will inhibit the absorption of other BCAAs. It is possible that less leucine is absorbed due to the transporters being occupied by other amino acids.

3. **Amount of amino acid**
   The amount of a specific amino acid that can be absorbed depends on the amount of its transporter. When the amount of a specific amino acid far exceeds its transporter capacity, the absorption percentage will be decreased or even significantly decreased. For example, the absorption rate for 1.2 millimolar (mM) leucine is 94% but for 20 millimolar (mM) it is only 52% (ref 10) possibly due to insufficient leucine transporter to bring leucine to the leucine receptors on the villi.

AstraGin® increases the amount of specific transporters so a greater amount of the amino acid it carries can be absorbed, and at a faster rate. When the amount of an amino acid exceeds the amount of its transporter, less of the amino acid is absorbed.

When the amount of an amino acid exceeds its transporter capacity, it may also be converted into other amino acid(s). This can affect the absorption of other amino acids.

Table 4 in reference 10 showed that the absorption rate for leucine at 20 mM concentration (approximate 3 g) was reduced to 52% while at 1.2 mM (approximate 0.2 g) concentration, the absorption rate was 94%.

Group	**Control**	**AstraGin®**	**% Increase**
Leucine intake	0.2 g	0.2 g	
Absorbed leucine (94%)	0.188 g	0.2 g (0.188 g*1.58 = 0.2 g)	6%
Leucine intake	3 g	3 g	
Absorbed leucine (52%)	1.56 g	2.46 g (1.56 g*1.58 = 2.46 g)	58%

Intestinal Metabolism

Amino acid metabolism in the intestinal epithelial cells and gut microbiota is involved in the key processes of intestinal homeostasis such as epithelium renewal, gut hormone secretion, gut barrier function and immune regulations. In previous studies, 30% of the absorbed leucine is metabolized in the small intestine for its own protein synthesis, oxidation, synthesis of transporters, and by the immune cells in the small intestine. To maintain clarity and simplicity, factors such as biosynthesis of leucine by microbes are not accounted for. AstraGin® has shown in an *in-vitro* study to increase leucine absorption in the small intestine by 58%.

Group	**Control**	**AstraGin®**
Leucine intake	3 g	3 g
Absorbed leucine (52%)	1.56 g	2.46 g (1.56 g*1.58 = 2.46 g)
Used by the gut (30%)	0.47 g	0.74 g
Used by the liver (10%)	0.11 g	0.2 g
Plasma leucine	0.98 g	1.52 g

Liver Metabolism

In the liver, amino acids serve as the building blocks of proteins (albumin, lipoproteins, transferrin, and retinol-binding protein); the regulators of intracellular protein turnover (protein synthesis and proteolysis); conjugators with bile acids; substrates for the syntheses of glutathione, taurine (essential for retinal, cardiac and skeletal muscle functions), glucose, lipids, and anti-inflammatory molecules; and protectors against toxic xenobiotics and pathogenic microorganisms. It has been shown that there is a positive association between a BCAA-rich diet and metabolic health, including the regulation of body weight, muscle protein synthesis, and glucose homeostasis.

The liver is a key metabolic organ which governs body energy metabolism. It acts as a hub to metabolically connect to various tissues, including skeletal muscle and adipose tissue. Increased amino acids increase de novo synthesis of glucose via gluconeogenesis. Increased amount of BCAAs increases recycling of glucose carbon via the glucose-alanine cycle. In an *in-vitro* study on HepG2 cells, AstraGin® was shown to increase the ATP level in HepG2 cells by 18% and leucine was likely involved in this increase.

Discussion

AstraGin® increases the amount of amino acid transporters so that a greater amount of amino acids are absorbed at a faster rate. The increased absorption and rate leads to increased and faster protein synthesis in the muscle, better circulation in the vascular system, and higher energy output in the liver, etc.

As an example, AstraGin® increased the leucine absorption rate and total amount (AUC) in Caco-2 cells by 58%. Using the data provided in reference 5, the total amount of absorbed leucine, amount used by the gut, liver, and final amount in the plasma are given in the following table.

Group	**Control**	**AstraGin®**
Leucine intake	3 g	3 g
*Absorbed leucine (52%)	1.56 g	2.46 g (1.56 g*1.58 = 2.46 g)
Used by the gut (30%)	0.47 g	0.74 g
*Used by the liver (10%)	0.11 g (1.56 g*0.7*0.1 = 0.11 g)	0.2 g (2.46 g*0.7*0.1*1.18 = 0.2 g)
Plasma leucine	0.98 g (1.56-0.47-0.11 = 0.98)	1.52 g
Plasma leucine	100%	154.84%
*Estimated total plasma leucine (endogenous leucine included)	3.28 g 0.98 g (ingested) + 2.29 g (basal leucine) = 3.28 g	3.81 g (1.52 g (ingested) + 2.29 g (basal leucine) = 3.81 g
*Estimated total plasma leucine (%)	100%	116.45%
Fraction of ingested leucine into plasma	30% (0.98 g/3.2 g = 0.3)	39.89% (1.52 g/3.81 g = 0.3989)

AstraGin® has also shown to increase the amount and rate of absorption of agmatine, arginine, β-alanine, citrulline, carnitine, creatine, leucine, histidine, lysine, taurine, tryptophan, and peptides. The health benefits of these amino acids ranges from NO synthesis, pain management, muscle endurance, energy production, muscle growth, immunity, gastric secretion, fatty acid conversion, calcium absorption, production of niacin, serotonin, and melatonin. Increased availability of these amino acids will facilitate greater benefits in these health areas.

Conclusion

The conventional concept and understanding that relates the amino acid absorption in the digestive tract to blood concentration is misguided. The absorbed amino acids are utilized by the splanchnic bed, small intestine, liver, and all abdominal organs included, before they are delivered to the blood for systemic circulation. As indicated in the “intestinal metabolism” and “liver metabolism”, amino acids are critical for the normal and proper functions of these abdominal organs, just like all other organs in the human body. Increased amounts of absorbed amino acids and at a higher rate increase the availability of amino acids to the entire human body and have a multitude of health benefits.

Next steps

Are you considering a new product formulation? The team at NuLiv Science is here to support your innovation towards quality products.

Get more information on AstraGin® today to begin the first step in making your next product a wellness success!

References

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