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Amino acids in dentistry

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Abstract

Amino acids have the potential of being classified as anti-caries nutrients, like fluorides and phosphates. Animal and in vitro studies clearly show that natural protein foods like fish flour, purified compounds like casein, or amino acids like glycine have significant caries-inhibitory and cariostatic effects.

It is conceivable that enrichment of sugar and sugar products with amino acids or protein concentrates to reduce their cariogenicity may soon be a reality if we expend more research efforts in this direction.

Since it is an amino acid, naturally occurs in a variety of foods. Particularly good sources for it include red meat, chicken products, and fish. It's also found in dairy products, such as cheese. Usually, people who eat meat and dairy should be able to get an adequate amount of the amino acid from their diet.

While not eating meat does limit your sources of amino acids somewhat, it is still possible to find the amino acid in some plant-based foods. It's found in beans, for example, as well as nuts and some green vegetables.

While you can find the amino acid in foods, it can also be added to oral care products and be used to help protect the teeth that way. While it's not yet an additive in toothpaste available over the counter, some in-office treatments designed to help people with sensitive teeth do contain it.

Along with eating more foods that are a good source of the amino acid, you can take a few other steps to continue to protect your teeth from decay or gum disease.

The aim of the review is to illustrate the beneficial effects of amino acids in oral health

Keywords: Amino acid, cariostatic, Gum disease, Dental caries

Introduction

Amino acids are basic unit of protein. Amino acids contain an amino group and a carboxylic group. Amino acids play major role in regulating multiple processes related to gene expression, including modulation of the function of the proteins that mediate messenger RNA (mRNA) translation[1].

Amino acids are utilized in formation of protein. If amino acids are deficient, then protein synthesis does not occur. As a result protein deficiency disease may occur. It is necessary to take balanced diet containing all essential amino acids[1].

Some amino acids are not synthesized in the body and it is necessary to take them in diet. Such types of amino acids are called essential amino acids. Some amino acids are synthesized in the body and there is no needs to take them in diet, such type of amino acids are called non-essential amino acids[2].

Some amino acids are synthesized in the body but their production is insufficient such type of amino acids are called semi-essential amino Amino acids are compounds that combine to make proteins. When a person eats a food that contains protein, their digestive system breaks the protein down into amino acids. The body then combines the amino acids in various ways to carry out bodily functions[2].

A healthy body can manufacture the other 11 amino acids, so these do not usually need to enter the body through the diet. Amino acids build muscles, cause chemical reactions in the body, transport nutrients, prevent illness, and carry out other functions[2].

Amino acid deficiency can result in decreased immunity, digestive problems, depression, fertility issues, lower mental alertness, slowed growth in children, and many other health issues. Each of the essential amino acids plays a different role in the body, and the symptoms of deficiency vary accordingly[1].

Classification

Essential amino acids	Non-essential amino acids
Histidine	Alanine
Isoleucine	Arginine
Leucine	Aspargine
Methionine	Aspartate
Penyl alanine	Cystine
Threonine	Glutamic acid
Tryptophan	Glycine
Valine	Ornithine
	Proline
	Serine
	Tyrosine

Histidine in oral health

Histidine as an Antioxidant The antioxidant activity of histidine is mediated by metal ion chelation, by the scavenging of reactive oxygen (ROS) and nitrogen (RNS) species, and by sequestering advanced glycation

The underlying mechanisms of the antioxidant effects of imidazole-containing compounds remain obscure.

L-histidine (HIS) is an essential amino acid with unique roles in proton buffering, metal ion chelation, scavenging of reactive oxygen and nitrogen species, erythropoiesis, and the histaminergic system. Several HIS-rich proteins (e.g., hemoproteins, HIS-rich glycoproteins, histatins, HIS-rich calcium-binding protein, and filaggrin)[3],

HIS-containing dipeptides (particularly carnosine), and methyl- and Sulphur-containing derivatives of HIS (3-methylhistidine, 1-methylhistidine, and ergothioneine) have specific functions. The unique chemical properties and physiological functions are the basis of the theoretical rationale to suggest HIS supplementation in a wide range of conditions.

Methotrexate is a widely used anticancer agent in oral squamous cell carcinoma that inhibits dihydrofolate reductase, an enzyme that generates tetrahydrofolate, an essential cofactor in nucleotide synthesis. A depletion of THF causes cell death by suppressing DNA and RNA synthesis. It has been suggested that the drain of cellular

pool of THF by dietary HIS supplementation might improve methotrexate efficacy and might enable reduced dosing of this toxic agent[3]

Leucine in oral health

Leucine is an essential amino acid for protein synthesis. Additionally, similarly to other amino acids, the carbon skeleton of leucine can be used to generate ATP.

However, leucine can also regulate several cellular processes such as protein synthesis, tissue regeneration, and metabolism.

Therefore, leucine supplementation has been studied in a variety of conditions such as aging, muscle lesions, protein/energy deprivation, obesity, and diabetes mellitus.

Persistently low leucine levels can result in decreased a petite, poor feeding, delayed eruption, and desquamation of gingival[4].

Other essential amino acids in oral health

Threonine

Threonine is necessary for healthy skin and teeth, as it is a component in tooth enamel, collagen, and elastin. It helps aid fat metabolism and may be beneficial for people with indigestion, anxiety, and mild depression[5].

Methionine

Methionine and the nonessential amino acid cysteine play a role in the health and flexibility of skin and hair. Methionine also helps keep teeth and nails strong. It aids the proper absorption of selenium and zinc and the removal of heavy metals, such as lead and mercury[5].

Valine

Valine is essential for mental focus, muscle coordination, and emotional calm. People may use valine supplements for muscle growth, tissue repair, and energy. Deficiency may cause insomnia and reduced mental function[5].

Isoleucine

Isoleucine helps with wound healing, immunity, blood sugar regulation, and hormone production. It is primarily present in muscle tissue and regulates energy levels.

Older adults may be more prone to isoleucine deficiency than younger people. This deficiency may cause oral wasting disorder like attrition, erosion, abrasion and abfraction, muscle wasting and shaking[5].

Phenylalanine

It helps the body use other amino acids as well as proteins and enzymes. The body converts phenylalanine to tyrosine, which is necessary for specific brain functions. Phenylalanine deficiency, though rare, can lead to poor weight gain in infants. It may also cause fatigue, and memory problems in adults[6].

Phenylalanine is often in the artificial sweetener aspartame which was once used as sugar substitutes which helps in decreasing dental caries, which manufacturers use to make diet sodas. Large doses of aspartame can increase the levels of phenylalanine in the brain and may cause anxiety and jitteriness and affect sleep.

People with a rare genetic disorder called phenylketonuria (PKU) are unable to metabolize phenylalanine. As a result, they should avoid consuming foods that contain high levels of this amino acid[6].

Tryptophan

Tryptophan is necessary for proper growth in infants and is a precursor of serotonin and melatonin. Serotonin is a neurotransmitter that regulates appetite, sleep, mood, and pain. Melatonin also regulates sleep. Tryptophan is a sedative, and it is an ingredient in some sleep aids. One study indicates that tryptophan supplementation can improve mental energy and emotional processing in healthy women.

Tryptophan deficiency can cause a condition called pellagra, which can lead to dementia, skin rashes, and digestive issues and delayed eruption of teeth[7].

Incorporating essential amino acids into the diet

Although it is possible to be deficient in essential amino acids, most people can obtain enough of them by eating a diet that includes protein. The foods in the following list are the most common sources of essential amino acids:

- Lysine is in meat, eggs, soy, black beans, quinoa, and pumpkin seeds.
- Meat, fish, poultry, nuts, seeds, and whole grains contain large amounts of histidine.
- Cottage cheese and wheat germ contain high quantities of threonine.
- Methionine is in eggs, grains, nuts, and seeds.
- Valine is in soy, cheese, peanuts, mushrooms, whole grains, and vegetables.
- Isoleucine is plentiful in meat, fish, poultry, eggs, cheese, lentils, nuts, and seeds.
- Dairy, soy, beans, and legumes are sources of leucine.
- Phenylalanine is in dairy, meat, poultry, soy, fish, beans, and nuts.
- Tryptophan is in most high-protein foods, including wheat germ, cottage cheese, chicken, and turkey[8].

These are just a few examples of foods that are rich in essential amino acids. All foods that contain protein, whether plant-based or animal-based, will contain at least some of the essential amino acids.

Amino acids in oral sub mucous fibrosis

One of the common diseases affecting collagen turnover and degradation is Oral Submucous Fibrosis (OSMF). OSMF is a chronic, progressive, scarring, potentially malignant disorder of the oral mucosa characterized by a juxta epithelial inflammatory reaction followed by a fibro elastic change in the lamina propria and associated epithelial atrophy.

Studies on amino acids are making a major contribution in understanding of disease. Amino acid therapies have been used successfully to prevent aging, heart disease, enhance memory, relieve stress, arthritis.

Various research states that OSMF, being a precancerous condition, with the progression of severity has an increased potential for malignant transformation, few amino acids which can be used as biological markers for the severity of the disease. However, further studies are needed to elucidate the potential of these profiles in the pathogenesis of OSMF and its implications in the malignant transformation potential of such condition[9].

Amino acids in dental caries

Amino acids and proteins have the potential of being classified as anti-caries nutrients, like fluorides and phosphates. Animal and in vitro studies clearly show that natural protein foods like fish flour, purified compounds like casein, or amino acids like glycine have significant caries-inhibitory and cariostatic effects.

It is conceivable that enrichment of sugar and sugar products with amino acids or protein concentrates to reduce their cariogenicity may soon be a reality if we expend more research efforts in this direction[10].

Amino acid in forensic odontology

There are several age-related changes that occur in proteins, like oxidation, isomerisation & racemization. Among these changes, racemization is the first order chemical reaction from levo or L-form to dextro or D form and highly correlates with age of the protein.

The principle behind racemization is that D and L amino acids have same molecular and structural formula[11].

These D and L forms are the mirror images of each other but cannot be superimposed like right and left hands.

Molecules of amino acids having carbon atom with four different groups, when subjected to plane polarized light, rotates the light in both right and left directions at equal degrees making amino acids optically inactive. In some cases, an enantiomer (L form or D form) is produced in excess because of the hindrance on one side of the molecules.

Such a mixture of two enantiomer, unlike a racemic mixture shows a net optical rotation and thus, it is said to be optically active. The rate at which molecules rotate light, forms the basis of study done for estimation of age[12].

Amino acid racemization is an age dependent, nonenzymatic changes of L-form amino acid to D-form amino acids and is considered to be one of the most reliable and accurate method.

In the living body, newly synthesized proteins are normally composed of L-form amino acids, although there are some exceptional peptides that are biologically synthesized using D-form amino acids. At the human body temperature of approximately 37 °C, amino acid residues in tooth enamel protein undergo racemization from L- to Dresidues at a rate of approximately 0.1% per year[13].

Racemization is a natural process which will eventually convert optically active compounds into a racemic mixture but would take about 100,000 years at 25 °C for all L amino acids present in living systems to undergo complete racemization to an equilibrium mixture.

Amino acids and saliva

Saliva contains hundreds of proteins and peptides (small chains of amino acids). Each of these amino acid aggregates create and support an ecological balance in healthy saliva. Many proteins have multiple activities and properties, and collectively their properties support important salivary functions.

Proteins and amino acids contribute to the following salivary functions: antibacterial, antifungal, antiviral, tissue coating, wound healing, remineralization, digestion, lubrication, buffering and tasting[14].

Mucins and lactoferrin are the only two proteins that are produced by all salivary glands. Mucins are a unique compound: 20% protein and 80% carbohydrate. Salivary protein composition does not remain static. It changes from infancy through adolescence and on into adulthood. Many salivary proteins contain a large amount of the amino acid proline, referred to as Proline Rich Proteins (PRP's). Proline rich proteins make up 70% of all salivary proteins and are responsible for the formation and function of the acquired enamel pellicle, the protein-rich barrier that functions as an initial enamel protector[15].

A less abundant amino acid, arginine is found free in saliva and plays a significant role in modulating oral pH values.

Many authors in the literature attempt to find out the real underlying factors using different tools which have evolved over time.

Kesel et al. in 1945 proposed the presence of various amino acids may prevent bacterial growth. They revealed that at least six amino acids and proposed they can be converted into ammonia nitrogen[16].

Golberg et al. in 1948 showed the presence of thirteen free amino acids in saliva. By the use of thin layer chromatographic techniques (1973), twenty free amino acids were detected in stimulated saliva. They suggest alanine, glutamic acid and glycine were present in higher concentration. However, they could not find any

difference between caries susceptible and caries resistant individuals[16].

Van Wuyckhuse et al. in 1995 found that the levels of free arginine and free lysine of caries-free adults were significantly higher than the individuals with the history of dental decay in stimulated parotid saliva[16].

Varnic et al. in 1991 determined amino acids by ion-exchange chromatography. A significantly lower level of salivary arginine and a complete lack of histidine were found in children with caries compared with a control group[16].

However, it is in contrast to our study, and arginine is in the urea circle and can be excreted. A higher risk of experiencing dental caries in the presence of free proline and absence of glycine in caries experience group, children aged 6–71 months whole saliva, was identified by Fonteles et al.

We can consider that amino acids are the source of substrate for micro-organisms and can provide different effects on teeth. However, we can propose, like most of the previous authors, that it may be utilised for their ability to enhance caries resistance in different fields of nutrition or by adding these materials to some chewing gums increasing the rate for caries prevention[16].

Amino acids in oral cancer

Studies from the past decades have proven the important role of amino acids in cancer metabolism in both a tumorigenic and tumor-suppressive way. Amino acids are involved in pathways that feed cancer cells and provide building blocks for cancer cell growth.

The TCA cycle highlights an important mechanistic example of amino acid involvement supporting cancer. Amino acids such as glutamate, BCAAs, and threonine fuel the TCA cycle intermediates, resulting in the release of ATP and providing the required energy for oncogenic activities[17].

Nucleotides, a critical building material for growth in normal and cancer cells, require amino acids as nitrogen and/or one-carbon donors (as a form of format) for their biosynthesis. Some amino acids can regulate lipid biosynthesis by filling the acetyl-CoA pool or altering lipogenic gene expression. Amino acids also influence ROS homeostasis and epigenetic regulation through methylation and acetylation, all of which can enhance tumor aggressiveness.

On the other hand, certain metabolic intermediates from amino acids can contribute to both tumorigenic and anti-tumorigenic activities. Nitric oxide (NO), a product of arginine metabolism (citrulline–NO pathway), can support tumor growth by promoting angiogenesis, but it can also act as a tumor suppressor, at least in part, by upregulating p5378.

Inhibition of amino acid metabolism is an active area of study in cancer metabolism; the field has yielded much success for cancer medications in vitro, but still faces many challenges to realize them in vivo. Some drugs targeting amino acid metabolism have been applied in a clinical setting and highlight the therapeutic potential of this mode of inhibition[17].

Recent advances

L-arginine is currently being included in certain toothpaste formulations as it is thought to protect against dentine hypersensitivity. Research states that L-arginine potentially can control dental plaque, and so may be beneficial in protecting against gum disease.

At present, around 10-15% of adults in the Western world have advanced gum disease which can lead to loose teeth and even tooth loss. Therefore, there is a clear need for better methods to control dental plaque."

Dental biofilms cause the formation of dental cavities, gingivitis and periodontal disease. Surveys indicate that 31% of adults in the UK have active dental cavities; and 45% have moderate or severe periodontal disease[18].

Most methods for dental plaque control involve use of antimicrobial agents, such as chlorhexidine, which are chemicals aimed at killing plaque bacteria, but they can affect sense of taste and stain teeth. Antimicrobial treatments have been the subject of debate about overuse in recent years.

Jakubovics et al in their study shows that the effects are only seen at very high concentrations of arginine, such as those that are currently being introduced into certain oral healthcare products. There is no evidence yet that lower concentrations found in foods such as red meats would have benefits for removal of dental plaque."

Researchers say the mechanism for how L-arginine causes the disintegration of the biofilms needs further study. These initial findings show that arginine can change how cells stick together, and can trigger bacteria within biofilms to alter how they behave so that they no longer stick to surfaces[19].

Conclusion

Thus the review concludes that amino acids, not only play a vital role in general health but also plays an enormous role in maintenance of good oral health.

Hence we believe that this review will open the gate for more research in future on the basis of amino acids and its potential benefits in oral health and dentistry.

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