International Research Journal of Biochemistry and Bioinformatics Vol. 12(5) pp. 1-4, October, 2022
Available online http://www.interesjournals.org/IRJBB

Review Article

Biological Effects of Tryptophan and Nicotine on Microorganisms

Elena Yaman*

Department of Internal Medicine, Faculty of Medicine, Hacettepe University, Ankara, Turkey

*Corresponding Author's E-mail: yamanelena@yahoo.com

Received: 01-Oct-2022, Manuscript No. IRJBB-22-76431; **Editor assigned:** 03-Oct-2022, PreQC No. IRJBB-22-76431 (PQ); **Reviewed:** 17-Oct-2022, QC No. IRJBB-22-76431; **Revised:** 22-Oct-2022, Manuscript No. IRJBB-22-76431 (R); **Published:** 29-Oct-2022 , DOI: 10.14303/2250-9941.2022.32

Abstract

L-tryptophan is the only protein amino acid (AA) containing an indole ring; through biotransformation in living things, it either aids in maintaining this chemical group in cells and tissues or degrades it by releasing a range of bioactive chemicals in both cases. Trp's small derivatives have a pleiotropic effect on homeostasis systems, according to studies on its biology. The pathways of Trp indole derivatives in humans are involved in protein turnover as well as the synthesis of the neurotransmitter and hormone serotonin (5-HT), the pineal gland hormone melatonin (MLT), and the trace amine tryptamine. Instead, the breakdown of the Trp indole ring is what defines the "kynurenine shunt," which produces cell-response adapters such L-kynurenine, kynurenic, and quinolinic acids, or the coenzyme nicotinamide adenine dinucleotide (NAD+). Bioremediation is one of the most promising methods for using potent, highly efficient microorganisms to clean up contaminated environments (Pavia CS et al., 2020).

Microbes may degrade the highly toxic heterocyclic compound nicotine and other tobacco alkaloids utilising specific enzymes and metabolic pathways. Following the metabolic conversion, these nicotinophilic bacteria utilise nicotine as their only source of carbon, nitrogen, and energy. Some of the known mechanisms for the breakdown of nicotine include the demethylation process in fungi, the pyridine pathway in Gram-positive bacteria, the pyrrolidine pathway, and variations of the pyridine and pyrrolidine pathways in Gram-negative bacteria. We discussed the enzymes and microorganisms that degrade nicotine as well as the biotechnological applications of nicotine intermediate metabolites (Gurusamy R et al., 2013).

Keywords: Nicotine, Bioremediation, Pleiotropic

INTRODUCTION

One of the 20 L-amino acids (AAs) that are incorporated into proteins during the process of mRNA translation is L-tryptophan (L-Trp). Living creatures contain this LNAA, or large neutral amino acid. In protein and peptide sequences, all Trp residues are commonly represented by the letter W. One of the nine necessary amino acids (AAs) for humans that cannot be produced endogenously and must be obtained from food, as demonstrated by tests on diet modification, is the AA L-Trp, which was discovered by the English scientist F. Hopkins in 1901. Trp has been the subject of decades of research in the field of human biology due to its transformation into a variety of tiny bioactive molecules with pleiotropic characteristics after absorption, in addition to being a stage in the production and turnover of proteins and peptides. Since these systems and organs-the gut-liver apparatus, the neuroendocrine, immunological, and CNS systems—are in charge of preserving the chemical, cellular, and behavioural homeostasis, it follows that changes in L-Trp-deriving chemicals can be linked to a wide range of metabolic disorders and syndromes. An imbalanced metabolism of this AA can notably impair these systems' ability to interact with and discern between stressors and stimuli, exogenous and endogenous antigens, nutrients, and xenobiotics during development. Serotonin, a neurotransmitter that has been around for a very long time, is one of the products of Trp that the body makes (Banani SF

et al., 2017). The key adaptive responses and responses to environmental changes in the human CNS, including mood-anxiety, cognition, nociception, impulsivity, aggressiveness, libido, eating behaviour, and body temperature, are known to be regulated by this biogenic amine. In addition to its role as a neurotransmitter, 5-HT also affects peripheral regions' activity, in particular the gastrointestinal, immune, and inflammatory responses, the growth of blood stem cells, and hemodynamic function. Anorexia or bulimia nervosa, obesity, autism, altered 5-HT transmission, and other conditions with peripheral symptoms including fibromyalgia, chronic fatigue syndrome, and irritable bowel syndrome have all been related to these conditions. The precursors of 5-HT include the circadian regulators N-acetyl-5-HT (NAS) and melatonin (MLT), which are mostly produced in the pineal gland but are also produced in the periphery where the two indoleamines serve as scavenger chemicals (Xia Y et al., 2004). The so-called "kynurenine shunt," which results in a variety of chemicals implicated in inflammation, immunological response, excitatory neurotransmission, and many other activities, is another important metabolic route of Trp in both animals and humans. Given that just a tiny fraction of endogenous/dietary L-Trp is converted into 5-HT, it's probable that adjustments to this AA's metabolism in tissues and bioavailability are essential for maintaining a healthy balance among all of its many paths and destinations. Additionally, 5-HT serves as a precursor for the circadian regulators melatonin (MLT) and N-acetyl-5-HT (NAS), which are mostly produced in the pineal gland but may also be detected in the peripheral nervous system where they act as scavenger chemicals. Trp's indole ring is broken down in vertebrates, including humans, by the so-called "kynurenine shunt," which produces a variety of compounds that are involved in a number of activities, including inflammation, immune response, excitatory neurotransmission, and many others. Since only a very small amount of endogenous/dietary L-Trp is converted into 5-HT, the bioavailability of this AA and/or changes in the control of its metabolism in tissues may be critical for maintaining a healthy balance between all of its various routes and fate. The majority of the world's tobacco (Nicotiana, Solanaceae family) is grown in Brazil, China, Cuba, India, and the United States (Price JH et al., 2002). According to statistics, 6.7 million tonnes of tobacco are produced each year. 3, 00,274 tonnes of waste nicotine are anticipated to be produced annually by the tobacco industry. Nicotine normally makes up the bulk of the alkaloid content of commercial tobacco, Nicotiana tabacum. Tobacco goods like cigarettes, cigars, chewing tobacco, and snuff were all made using all or part of the tobacco leaf as the raw material. It was estimated that smoking contributed to 4.9 million deaths in the year 2000. By 2020, it is predicted that there would be more than 9 million fatalities yearly. Due to the increased usage of tobacco products, the industry created high-nicotine solid and liquid tobacco wastes. The trash produced by the tobacco industry has an average nicotine content of 18 g per kilogramme of dry weight (Kutay H et al., 2006). The Environmental Protection Agency has classified these toxic release inventory (TRI) chemicals as non-recyclable powdered tobacco wastes (EPA). When the level of nicotine exceeds 0.05% (w/w), anything is deemed "toxic and dangerous" by European Union Regulations (EUR) (Wei L et al., 2017).

Chemical Composition of Living Things

Earth's molecular evolution has selected the 20 L-AAs' -R groups' chemical structure as the one most suitable for the synthesis of proteins. In proteins generated from indole, a bicyclic ring composed by benzene and a pyrrole group joined to the -carbon by a -CH2-group, L-Trp is the only amino acid (AA) present. Trp's chemical makeup includes an indole ring, which confers to it some of the most hydrophobic qualities of all protein AAs (Singh I 1997). Because L-Trp possesses the most basic structure of all possible indole AAs, it has been "retained" as a part of proteins in living things. Other AAs might theoretically be produced from indole, but only L-Trp has done so. Prephenate is created from chorismate by the enzyme chorismate mutase, which then enters a 3-branch route to produce Tyr and Phe (Tian T et al., 2010). Chorismate is recognised by an enzyme called anthranilate synthase, which then adds an amino group from the amino acid glutamine to it to create anthranilate and pyruvate. Pyruvate is subsequently transformed into Trp through five further biochemical steps. Genes and chemical processes used in the manufacture of Trp in bacteria are similar to those in plants or fungus. But in bacteria, plants, and fungi, other regulatory systems follow this metabolic cycle. The synthesis of Trp in bacteria is controlled by the Trp operon, one of the best-studied forms of bacterial gene expression regulation. The Trp operon is activated or repressed depending on the levels of this AA inside the cell (Hamilton JA et al., 2002).

Proteins and Peptides Containing Tryptophan Residues

Particularly, proteins and peptides have distinctive properties that encourage protein-protein, protein-peptide, or protein-biomolecule structural hydrophobic interactions thanks to the Trp indole ring in -R residues. As previously mentioned, the prevalence of Trp residues in polypeptides is noteworthy (Craveiro Sarmento AS et al., 2018). The Trp indole ring has the ability to stabilise structures, domains, and contacts through Van der Waals forces, and the indole-N has the tendency to function as a hydrogen bond donor, suggesting that this AA is also involved in protein binding and recognition (Connor RF et al., 2007). For a protein to be stable when put together with the phospholipid bilayer, Trp -R groups must be present in particular domains, such as the trans-membrane domains of membrane-bound proteins. Hydrophobic interactions between proteins and peptides, or between these and other physiologically active molecules, are essential for cell physiology (Ibba M 2002).

The need for tryptophan and its presence in food

One of the primary findings from the previous paragraphs is the significance of Trp for life. In actuality, either for the shikimate and chorismate pathways in plants or for the Trp operon in bacteria, the biosynthetic pathway for Trp is energy-intensive and requires the production of a number of enzymes and substrates (Andreini C et al., 2012). This likely explains why L-Trp is an uncommon AA in the alimentary chain and why it must be carefully regulated in animal cells and tissues. Leucine is the most common AA and makes up 9% of proteins, compared to 5% for other AAs and 1-2% for Trp residues. There has been a lot of interest in the Trp uptake model that regulates its transit through the blood-brain barrier (BBB) (Feig AL et al., 2002). In fact, it has been found that a major role in this is played by insulin and other large neutral AAs, including valine (Val), leucine (Leu), isoleucine (Ileu), Tyr, and Phe. LNAAs really compete with one another for the same transporter system across the BBB when insulin is present. This explains why a protein-rich diet increases plasma Trp levels but not its brain absorption. As a result, meals rich in carbs are beneficial for the CNS absorption of trp. After a meal rich in carbs, the raphe nuclei produce more 5-HT. Mammals have been used extensively to study how carbohydrates affect insulin production and AA clearance from plasma (Vuong P et al., 2008).

Nicotine

Nicotine is a toxic chemical that causes peripheral artery disease and lung cancer from tobacco usage. Even though tobacco cigarette smoke contains more than 4000 other compounds, nicotine is the primary component (Alic AS et al., 2016). Nicotine has a blood half-life of around two hours and causes severe vascular issues. Cancer, deformities, and gene mutation have all been connected to nicotine. Numerous dangerous intermediate nicotine metabolites, such as N'-nitrosonornicotine, 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone, cotinine, and N-nitrosamine, contribute to tobacco lung cancer (Kelley DR et al., 2010). Several cellular processes, such as the generation of oxidative radicals, apoptosis, and cell hyperplasia, as well as the improvement of gene expression for the release of hormones and the regulation of enzyme activity, can be affected by nicotine's neurotoxin-developmental effects (Salmela L et al., 2011).

Nicotine microorganism degradation

It is possible to physically and chemically break down the nicotine in cigarettes. These methods are expensive, time-consuming, and usually require solvent extraction processes. Bioremediation is one of the potential approaches of using bacteria to purify contaminated environments. The tobacco wastes were subjected to a biomethanation procedure that removed 60% of the nicotine, 75.6% of the chemical oxygen demand, and 80% of the biological oxygen demand. Aerobic composting is a useful method for getting rid of 50% of the volume and mass of tobacco solid wastes as well as 80% of the nicotine (Chen D et al., 2014). The biological method makes use of several nicotine-degrading bacteria and fungi. These green biological technologies are widely used in the treatment of wastewater due to their great efficacy and low cost. Reports claim that bacteria that break down nicotine can quickly adapt to a polluted environment.

DISCUSSION

L-tryptophan biochemistry is at the centre of the convergent nutritional, neuroendocrine, and immune pathways through a variety of molecular effectors. Each of these routes is probably to blame for crucial, complicated, and severe illnesses and syndromes, as was indicated in the paragraphs above. The knowledge of Trp metabolism and its implications for clinical genetics and research has improved as a result of advances in molecular biology and applied biochemistry. In reality, new viewpoints are beginning to emerge; in particular, it is becoming increasingly clear that multidisciplinary and multifactorial methods are necessary for treating diseases with confusing aetiological pathophysiology. As a result, patients with the same illness might be divided into groups that have symptoms or treatment-associated responses due to particular biochemical patterns that are comparable but distinct (Chen Q et al., 2017). For instance, the identification of biochemical clusters within neuropsychiatric illnesses or other complex diseases might add to the evidence. 2, 5- or 3, 5-disubstituted pyridines are catabolized from 6HLN and HSP to produce the insecticide imidacloprid, which is used to treat Parkinson's disease. One of these physiologically functional metabolites is SIB-1508Y. The formation of aminolevulinic acid, a universal precursor, can begin chemically from 2,5-DHP, a key nicotine intermediary metabolite. Medications that combat cancer, herbicides, plant growth regulators, and porphyrins like heme and chlorophyll are all produced using this precursor.

CONCLUSION

Tryptophan is an essential amino acid (AA) that varies from all other protein AAs biologically in that it is linked to stress and environmental adaptation. All living things have conserved tryptophan derivatives. The molecular effectors of their indole-conserving or indole-disrupting fates can be up- and downregulated by a number of variables that can be implicated in a range of complicated illnesses and syndromes in humans. The use of high-dimensional biology tools is intended to provide more understanding of the control over Trp content in cells, its availability for human nutrition, and its function in disease pathogenesis. Genetics and molecular biology methods are used to investigate the components of Trp pathways. Trp research also takes into consideration the effectiveness, monitoring, and personalising of pharmacological treatments as well as the development of innovative therapeutic strategies. Environmental deterioration is one of the main problems the world is now experiencing. The tobacco industry created significant amounts of nicotine. Nicotine harms the ecosystem and

has an impact on human health when it is consumed straight into soil. Significant microorganisms break down the dangerous chemical nicotine. This essay has examined every gene and metabolic pathway related to nicotine metabolism. These bacteria create a variety of intermediate metabolic compounds with potential medical applications when breaking down nicotine. Bioremediation is one of the most efficient processes for converting hazardous chemicals into helpful ones. To bio-remediate nicotine-contaminated environments, these microorganisms that degrade nicotine can be used. For use in the pharmaceutical business, these intermediate nicotine metabolites might be synthesised on a massive scale.

REFERENCES

1. Pavia CS, Plummer MM (2020). Clinical implications of nicotine as an antimicrobial agent and immune modulator. Biomedicine & Pharmacother. 129: 110404.
2. Gurusamy R, Natarajan S (2013). Current status on biochemistry and molecular biology of microbial degradation of nicotine. Scientific World Journal.
3. Banani SF, Lee HO, Hyman AA, Rosen MK (2017). Biomolecular condensates: organizers of cellular biochemistry. Nat Rev Mol Cell Biol. 18: 285-298.
4. Xia Y, Yu H, Jansen R, Seringhaus M, Baxter S, et al (2004). Analyzing cellular biochemistry in terms of molecular networks. Annu Rev Biochem. 73: 1051-1087.
5. Price JH, Goodacre A, Hahn K, Hodgson L, Hunter EA, et al (2002). Advances in molecular labeling, high throughput imaging and machine intelligence portend powerful functional cellular biochemistry tools. J Cell Biochem Suppl. 87: 194-210.
6. Kutay H, Bai S, Datta J, Motiwala T, Pogribny I et al (2006). Downregulation of miR-122 in the rodent and human hepatocellular carcinomas. J Cell Biochem. 99: 671-678.
7. Wei L, Huang X (2017). Long-duration effect of multi-factor stresses on the cellular biochemistry, oil-yielding performance and morphology of Nannochloropsis oculata. Plos one. 12: e0174646.
8. Singh I (1997). Biochemistry of peroxisomes in health and disease. Mol Cell Biochem. 167: 1-29.
9. Tian T, Wang Y, Wang H, Zhu Z, Xiao Z (2010). Visualizing of the cellular uptake and intracellular trafficking of exosomes by live-cell microscopy. J Cell Biochem, 111: 488-496.
10. Hamilton JA, Kamp F, Guo W (2002). Mechanism of cellular uptake of long-chain fatty acids: Do we need cellular proteins? Mol cell biochem. 239: 17-23.
11. Craveiro Sarmento AS, de Azevedo Medeiros LB, Agnez-Lima LF, Lima JG, de Melo Campos JTA (2018). Exploring seipin: from biochemistry to bioinformatics predictions. Int J Cell Biol.
12. Connor RF, Roper RL (2007). Unique SARS-CoV protein nsp1: bioinformatics, biochemistry and potential effects on virulence. Trends microbial. 15: 51-53.
13. Ibba M (2002). Biochemistry and bioinformatics: when worlds collide. Trends Biochem Sci. 27: 64.
14. Andreini C, Bertini I (2012). A bioinformatics view of zinc enzymes. J inorg biochem. 111: 150-156.
15. Feig AL, Jabri E (2002). Incorporation of bioinformatics exercises into the undergraduate biochemistry curriculum. Biochem Molecul Biol Edu. 30: 224-231.
16. Vuong P, Bennion D, Mantei J, Frost D, Misra R (2008). Analysis of YfgL and YaeT interactions through bioinformatics, mutagenesis, and biochemistry. J bacteriol. 190: 1507-1517.
17. Alic AS, Blanquer I, Dopazo J, Ruzafa D (2016). Objective review of de novo stand-alone error correction methods for NGS data. WIREs Comput Mol Sci. 6: 111-146.
18. Kelley DR, Schatz MC, Salzberg SL (2010). Quake: Quality-aware detection and correction of sequencing errors. Genome Biol. 11: R116.
19. Salmela L, Schroder J (2011). Correcting errors in short reads by multiple alignments. Bioinformatics. 27: 1455-1461.
20. Chen D, Hwu WM, Heo Y, Ma J, Wu XL (2014). BLESS: Bloom filter-based error correction solution for high-throughput sequencing reads. Bioinformatics. 30: 1354-1362.
21. Chen Q, Jiang P, Li W, Li J, Wong L, et al (2017). MapReduce for accurate error correction of next generation sequencing data. Bioinformatics. 33: 3844-3851.