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Importance of amino acids as therapeutic agents

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Abstract

There has been much written about the diverse functions of amino acids in foods, illnesses, and creatures, among other things. They have been recognized as both regulators of an organism's physiological processes and indicators of illnesses. Growing data during the last few decades has demonstrated the enormous potential of AAs in the treatment of disease. Additionally, AAs demonstrated remarkable efficacy in disengaging biofilm, suggesting that they may be able to prevent microbial infection. It can also successfully stop the spread of cancer cells. In this article, we examined current research on the therapeutic potential of AAs for the treatment of neurological disorders or tissue/organ damage, improvement of reproductive function, and suppression of cancer cell proliferation.

Keywords: Amino acids; Molecular targets; Antibacterial activity; Tryptophan; Diketopiperazine; Xanthone moiety

1. Introduction

Given their crucial roles as intermediates in metabolism and as building blocks for proteins, amino acids are the most significant compounds in nature. Protein folding, native three-dimensional structure, and stability are all determined by the amino acid sequence. Furthermore, the unique environment that permits protein action and regulation is determined by the chemical characteristics of the amino acid residues that compose the active site. Particularly, compounds with an amine group, a carboxylic acid group, and a side chain are known as amino acids. In biochemistry, amino acids are highly significant, and when we talk about amino acids, we usually mean α-amino acids. Proteins are composed of molecules of amino acids joined together. The types and sequence of amino acids involved determine this sort of protein (Shi, Hussain and Zhao, 2022; Zhang *et al.*, 2022). Conjugation of amino acids or peptides to tiny bioactive compounds is the most effective and promising strategy used in biomedical research to create new leads with increased potency. There is currently a strong tendency for conjugating amino acids and peptides to tiny bioactive compounds by taking advantage of the likelihood and optimal interaction of amino acids with the biological system. Additionally, a number of convincing studies have been conducted and published in the literature to demonstrate the value of amino acid conjugation in enhancing the bioactive molecule's solubility, selectivity and stability. (Bardaweel, 2014) (Amraibure Odia and Oaikhena Zekeri Esezobor, 2016)

2. Applications of amino acids as therapeutic agents

2.1. Molecular targets for antibacterials based on amino acids

The majority of the enzymes involved in the manufacture of peptidoglycan (murein), a major component of the bacterial cell wall, are the molecular targets of amino acid-based antibacterials. They catalyze certain steps in the MurA-F

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pathway, which forms oligopeptide substituents from N-acetylmuramic acid residues (Nowak, Skwarecki and Milewska, 2021).

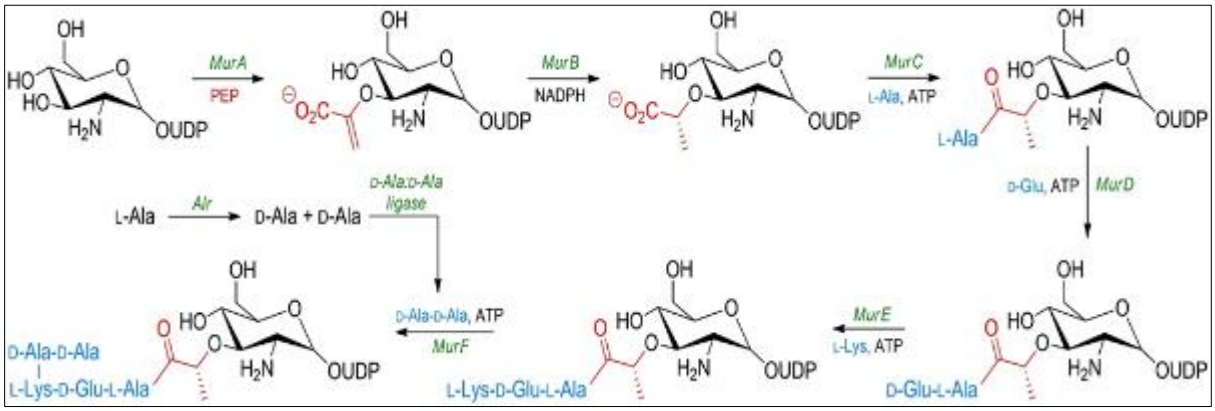

Figure 1 Synthesis of the peptidoglycan (murein)

2.2. Anti-viral activity of diketopiperazine derivatives of tryptophane

A variety of new tryptophan derivatives including diketopiperazine (DKP) to enhance the anti-viral activity of tryptophan after assessing the biological activity of the acyl hydrazon moieties (Liu *et al.*, 2014). To increase the range of possible agricultural uses for the recently synthesized tryptophan derivatives, additional research was done on their fungicidal and larvicidal properties. With the natural amino acid L-tryptophan as the starting material, we could readily achieve the synthesis of target compounds by esterification, amidation, cyclization, and condensation processes. The majority of these derivatives demonstrated stronger antiviral activity than L-tryptophan, according to the bioactive results. The majority of these derivatives have improved antiviral activity since the acylhydrazone structure was added, suggesting that the acylhydrazone moiety was crucial in enhancing the antiviral activity (Xie *et al.*, 2020; Zhang *et al.*, 2022)

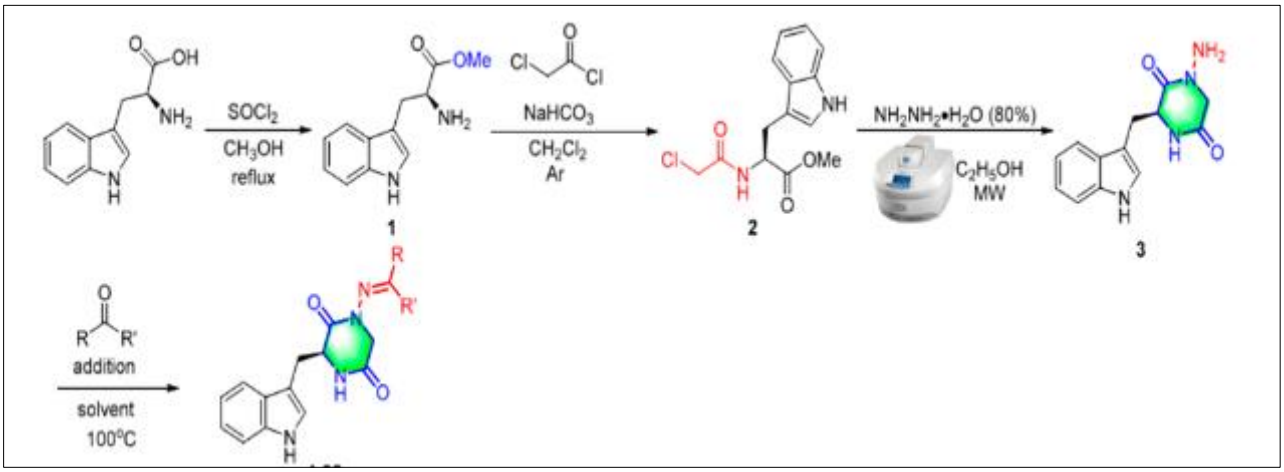

Figure 2 Synthesis of diketopiperazine- containing derivative of tryptophan

2.3. Antiviral, anticancer and anti-ulcer activities of amino acids

Protein modifications involving cysteine residues are crucial for the creation of new classes of pharmacological drugs because of the amino acids thiol moiety's involvement in oxido-reduction processes, as well as its nucleophilic character and easy reactivity with electrophiles. By using these techniques, new antivirals have recently been developed, primarily through the interaction of zinc finger proteins with disulfides and their derivatives. This method worked very well for creating new anti-HIV and anti-HPV medications. Along with the development of gastric H+/K+-ATP-ase inhibitors as anti-ulcer medications, several novel anticancer therapeutic strategies have also been described. These strategies mostly target tubulin, Ras, and farnesyl transferase, among other targets. Finally, this special amino acid presents incredibly intriguing opportunities for the development of useful pharmacological agents (Scozzafava, Mastrolorenzo and Supuran, 2001).

2.4. Antibacterial and anti-inflammatory activities of xanthone conjugated amino acids

Analytical and spectroscopic techniques were used to synthesize and characterize a number of new xanthone conjugated amino acids. An assessment was conducted on the in vitro antibacterial and anti-inflammatory properties of all the produced analogues (2–23). When compounds 7, 8, 9, 12, 18, 19, 20, 21, and 23 were compared to the antibacterial and antifungal reference medications gentamicin and bavistin, respectively, they demonstrated outstanding antimicrobial activity. Comparing compounds 7–12 and 18–23 to the common medication indomethacin, they demonstrated strong anti-inflammatory action. Tryptophan, tyrosine, phenylalanine, proline, and cysteine conjugated compounds had good antibacterial and anti-inflammatory effects, according to the preliminary structure-activity relationship. The contribution of amino acids' hydrophobicity and aromaticity may help to explain this. All of the synthesized compounds undergone molecular docking experiments, compounds 20, 21, and 23 exhibited the highest antibacterial docking scores, while compounds 9, 20, and 22 displayed the highest anti-inflammatory docking scores (Dahiya, Kumar and Yadav, 2008; Chen *et al.*, 2017)

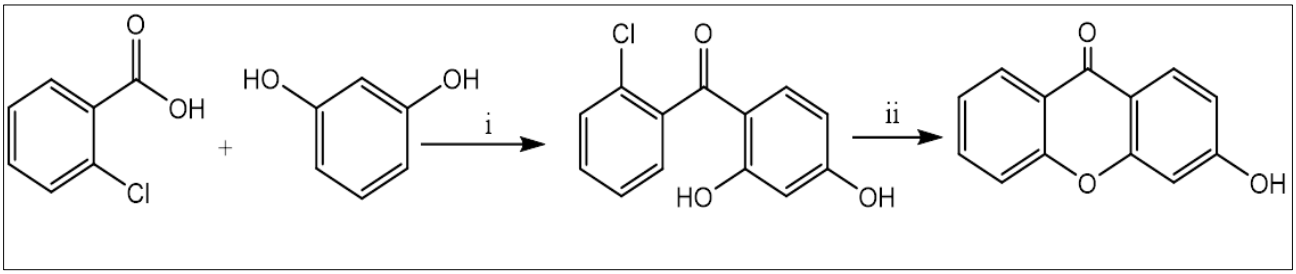

Figure 3 Synthesis of xanthone reagents, i= anhydrous zinc choloride, 120 ℃, II = NaOH, DMSO, 80 ℃

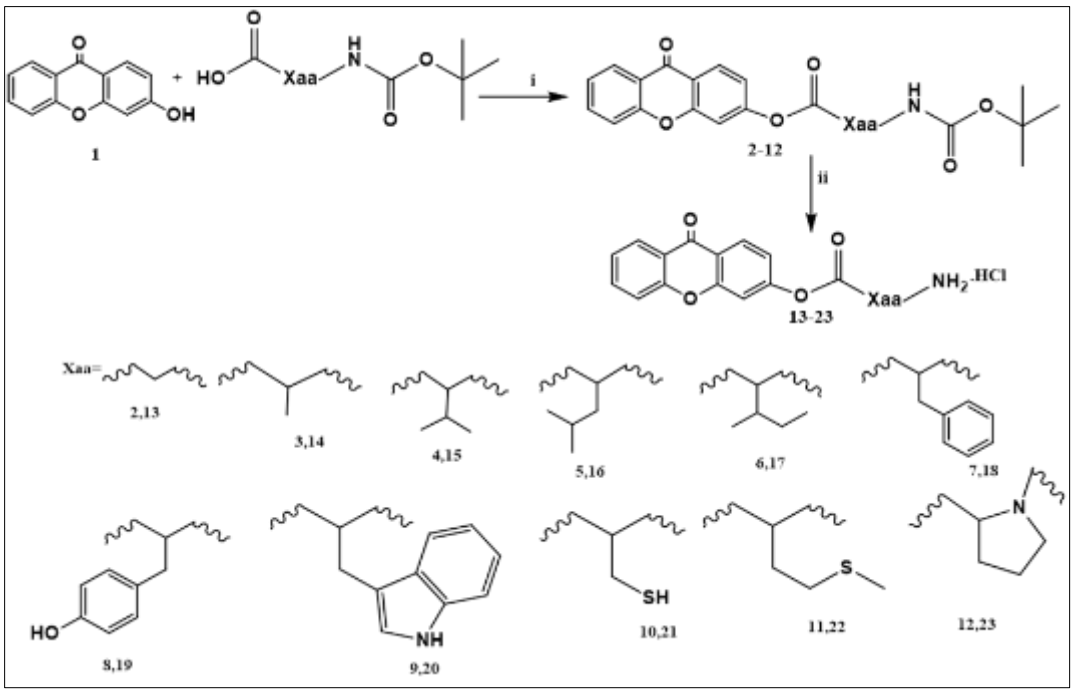

Figure 4 Synthesis of xanthone conjugated amino acids, i= DMF, HBTu,rt ii= hci dioxane, 45 min , rt

2.5. N-aryl amino acids as antimicrobial agents

Remain over the bacterial resistance to modern antibiotics and the recurrence of many illnesses following multiple treatment regimens. Many molecules depend on arylated amino acids as necessary synthons, acting as fundamental building blocks in the synthesis of heterocycles of nitrogen having different biological functions. The N-aryl amino acids were produced by combining various 4-substituted fluorobenzene using various amino acids using a base free of metals-induced aryl halide amination reaction (A. D. Osinubi *et al.*, 2020). They are important synthons in drug discovery and

development because they are widely distributed in antimicrobial peptides, which have demonstrated a broad spectrum and strong antibacterial activity. The most effective antibacterial compounds were A and B against all examined bacterial strains, with the exception of Bacillus subtilis, which proved resistant to the test compounds. It's interesting to note that compounds A and B both displayed large inhibition zones against four bacterial species that were screened—Streptococcus pneumoniae, Staphylococcus aureus, Escherichia coli, and Proteus mirabilis which were resistant to streptomycin. Moreover, Compound A showed the largest zone of inhibition against Staphylococcus aureus among the four microorganisms. The existence of the aromatic ring and the action of the amino acids, which are precursors in numerous biological processes, are responsible for the noteworthy antibacterial properties of the N-aryl amino acids described in this study. significant bioactive chemicals, making them stand out as potential starting points for the creation of new drugs to fight bacterial resistance(A. Osinubi *et al.*, 2020; Osinubi, Asekun and Familoni, 2023)

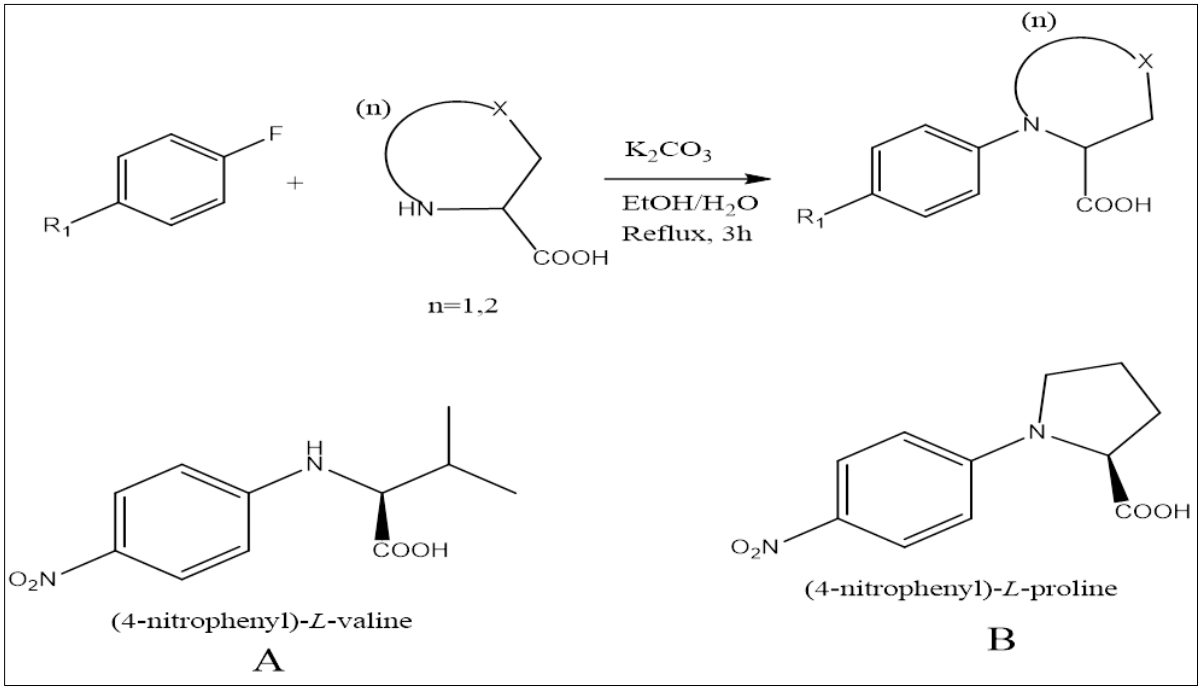

Figure 5 Synthesis of N-arylated amino acids

3. Conclusion

Amino acids are highly important as sources for synthesis of derivatives having therapeutic activities, biological studies proved that these compounds have antibacterial, antiviral, antifungal, anti-ulcer and anticancer activities, so they are promising targets for treatment of different types of illnesses. Amino acid derivatives are positioned to continue leading the way in medicinal innovation as studies continue to reveal new mechanisms and uses thereby enhancing patient outcomes and making a substantial contribution to the development of customized medicine.

Compliance with ethical standards

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This study was carried out on its own dime without funding assistance.

Disclosure of conflict of interest

The writers have stated categorically that they do not have any competing interests to disclose.

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