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# Polyamines: As Futuristic Feed Additives

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**Abstract**

Polyamines (PAs) are an essential class of metabolites found throughout all kingdoms of life. They are derived from amino acids, intestinal bacteria, exfoliated enterocytes and supported from diet. They are the key compounds that play crucial role in cell proliferation, growth and differentiation. They also exert significant effects on embryonic development, implantation, embryonic diapause, placentation, angiogenesis and fetal development. Therefore, we discuss their functions, synthesis, sources and future prospects of polyamines.

**Keywords:** Animals; Feed additives; Health; Performance; Polyamines

## Introduction

Polyamines are ubiquitous poly-cationic molecules that contain two or more amino groups. Polyamine especially the spermine was first reported by Leeuwenhoek in 1678 as a component of seminal plasma. They are low molecular weight organic compounds present in all living cells and exert important impacts on growth and development of animals. Polyamines metabolism is regulated by ornithine decarboxylase [1]. In mammals, they are synthesized from different sources viz. de novo synthesis by amino acids, such as arginine, proline, methionine and L-ornithine by decarboxylated S-adenosyl-methionine; import from the diet and also produced by intestinal microflora [2] Moreover, another source of polyamines derived from exfoliated enterocytes known as luminal sources comparatively rich in cellular contents of polyamines [3]. Mammals produce only spermine, spermidine, and their precursor i.e. diamine putrescine. Their incorporation in the diet of animals can improve growth, health and production performance. Thus, they act as alternative feed additives for livestock in near future. Due to their beneficial potential this paper covering their synthesis, metabolism, sources, important functions and their future perspectives.

## Sources

Polyamines are mainly obtained from the diet or produced by intestinal microflora [4]. Another source is luminal source (cellular contents of exfoliated enterocytes comparatively rich in polyamines) [5]. The wide variations in the concentration of polyamines in different foods are reported i.e. meat, fish and meat products are high in putrescine and spermine but low in spermidine, whereas, plant-derived foods are high in putrescine and spermidine [6].

Binh et al. [7] study reported polyamine content of Asian foods and that gave the idea that the highest putrescine levels were found in maize, citrus fruits, grapefruit, peas, soybeans, and other beans, whereas, spermidine concentrations were found to be highest in soybeans, other beans, and vegetables. However, spermine concentrations were high in edible offal, mollusks, meats, soybeans, and other beans. Generally, foods of plant origin tended to have higher contents of spermidine compared to spermine and foods of animal origin had the opposite composition [7]. Human and other mammals' milk contain substantial amounts of spermine and spermidine with minute quantity of putrescine [8].

## Synthesis

Polyamines are synthesized by conversion of arginine (amino acid) into ornithine in the presence of arginase enzyme, which is decarboxylated by ornithine decarboxylase (ODC1) to produce putrescine and then it is converted to spermidine and spermine in the traditional pathway. Recent study of Lenis et al. [9] has point out the existence of non-classical pathway for generation of putrescine from the amino acids (arginine and proline) in animal cells. The enzyme arginine decarboxylase (ADC) is required for the conversion of arginine into agmatine, which is hydrolyzed by agmatinase to form putrescine. However, proline is oxidized in the presence of proline oxidase to produce pyrroline-5-carboxylate, which undergoes transamination with glutamate to form ornithine for decarboxylation process by ODC1 [10].

## Important functions

Polyamines are indispensable for cell proliferation. They showed higher concentration in rapidly growing tissues, which are having regenerative as well as growth-promoting hormonal stimuli that enhance their synthesis and content. Treatment of cultured cells with ODC inhibitors such as di-fluoromethylornithine (DFMO)

led to a virtually complete loss of putrescine and spermidine but little change in spermine and halted cell proliferation. Polyamines are also believed to be involved in intestinal growth and its maturation [11]. Dietary incorporation of putrescine is positively effective on the small intestinal villus height and crypt depth [12], which play vital role for digestion, absorption and better utilization of dietary nutrients. In addition to growth promoting effects they also exhibit anti-oxidant properties via scavenging reactive oxygen species (ROS) thus protecting DNA, proteins and lipids from oxidative damage [13].

El Halfawy & Valvano [14] reported that putrescine also reduces antibiotic related oxidative stress which might be due to the scavenging of free radicals like ROS and hydrogen peroxide. Research evidences reported that polyamines regulate angiogenesis and early embryogenesis [15]. Recent studies, reported that many viruses have been shown to entail that polyamines are required for their replication cycle, including DNA and RNA polymerization, nucleic acid packaging, and protein synthesis [16]. Another important function of polyamine, especially spermine has been recently discovered that it could be considered as an activator and stabilizer for bovine trypsin [17].

## Conclusion and Future Perspectives

Polyamine functions are so varied and offer wider range that are hard to provide a comprehensive overview that covers all aspects. They are an essential part of the cellular milieu and influence almost all metabolic reactions either directly or indirectly. It is clear that close regulation of the free polyamines are essential for normal growth, development and mammalian physiology. There is little information available regarding polyamines content and their composition in most common food stuff and hence efforts should be made in this regard. Finally, the beneficial potential of polyamines is a multidisciplinary field that affords an opportunity to consider life in its biologically widest and evolutionarily deepest extent and has immediate biomedical and biotechnological relevance in animal as futuristic feed additives.

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