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Review

Uric acid in plants and microorganisms: Biological applications and genetics - A review

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GRAPHICAL ABSTRACT

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ABSTRACT

Uric acid increased accumulation and/or reduced excretion in human bodies is closely related to pathogenesis of gout and hyperuricemia. It is highly affected by the high intake of food rich in purine. Uric acid is present in both higher plants and microorganisms with species dependent concentration. Urate-degrading enzymes are found both in plants and microorganisms but the mechanisms by which plant degrade uric acid was found to be different among them. Higher plants produce various metabolites which could inhibit xanthine oxidase and xanthine oxidoreductase, so prohibit the oxidation of hypoxanthine to xanthine then to uric acid in the purine metabolism. However, microorganisms produce group of degrading enzymes uricase, allantoinase, allantoicase and urease, which catalyze the degradation of uric acid to the ammonia. In humans, researchers found that several mutations caused a pseudogenization (silencing) of the uricase gene in ancestral apes which exist as an insoluble crystalloid in peroxisomes. This is in contrast to microorganisms in which uricases are soluble and exist either in cytoplasm or peroxisomes. Moreover, many recombinant uricases with higher activity than the wild type uricases could be induced successfully in many microorganisms. The present review deals with the occurrence of uric acid in plants and other organisms specially microorganisms in addition to the mechanisms by which plant extracts, metabolites and enzymes could reduce uric acid in blood. The genetic and genes encoding for uric acid in plants and microorganisms are also presented.

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Introduction

Uric acid is one of the most important nitrogen compounds in animal and plant bodies. It consists of 2,6,8 trihydroxypurine existing as a keto-enol tautomerism that under physiological conditions can easily be converted to the corresponding urate [1]. It derived from purine, two of which, adenine and guanine, are present in DNA and RNA. In Human, both uric acid and urate are accumulated in the form of calculi in the joints and/or connective tissues causing arthritis and rheumatic pain. They may also deposit in kidneys and/or ureters causing kidney disease or failure [2].

Uric acid is either produced when the body breaks purine occurred naturally [3] (Fig. 1) or supplied from certain foods. Consequently, some animal and plant foods with high purine contents should be avoided from diet especially in persons suffer from gout, as the overproduction of uric acid can induce hyperuricemia which is linked to gout [4].

The normal level of uric acid in the blood is between 3–7 mg/100 mL, which is required to human and animal bodies as antioxidant and prevents damage of blood vessels lining so protect them. Low purine diets including plants, often required to treat gout. The average daily meal for adult in United States contains about 600–1000 mg of purines. Recent research has shown that plant purines (fruits and vegetables) have risk of uric acid accumulation but lower than that of meat and fish [5].

Production of uric acid by fungi and bacteria

Early, Jarmai [6] and Hutyra and Marek [7] reported that gout in birds had been caused by smut fungus *Ustilago maydis*, a common causal agent of moldy corn. Oosporin, a mycotoxin secreted by *U. maydis* induce gout in chickens and turkeys [8,9]. Furthermore, Constantini [10] reported that gout and hyperuricemia have been induced in animals by the fungal species *U. maydis*, *Chaetomium trialterale*, *Saccharomyces cerevisiae*, and *Candida utilis*. It is also induced by mycotoxins, aflatoxin, ochratoxin, Oosporin, and oxalic acid. Other fungal metabolites such as cyclosporine, ergotamine, and penicillin have been found to induce gout [10].

Gout is documented to be etiologically linked to beer, a *Saccharomyces* fermented beverage. Researchers found that beers contain significant quantities of ochratoxin and large amount of uric acid produced by the yeast *Saccharomyces* sp. [10] and accumulated in its vacuoles [11]. They also indicated that drinkers of beer and wine and people who often consume yeast foods such as bread and cheese are more susceptible to develop gout [10] (Table 1). Ochratoxin, a series of nephrotoxins produced by several species of the genera *Aspergillius* and *Penicillium* was found in beer and causes gout as early detected by many authors [10,12–14]. A synergistic interaction may occur between the alcohol from beer or yeast-fermented wine and ochratoxin. In fact, a study performed with 61 gouty men revealed that nearly all of them were beer drinkers [10].

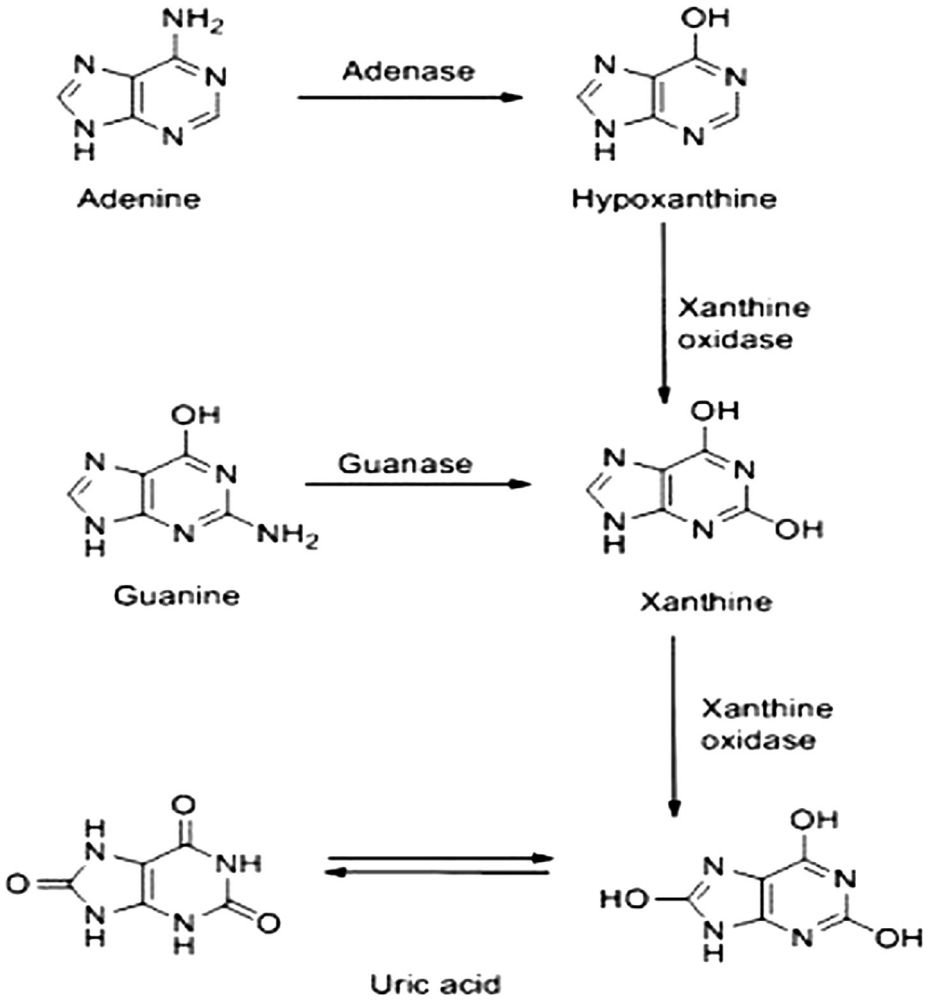

Fig. 1. Production of uric acid from purines. Adapted from Xiang et al. [3].