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Some biological perspectives of *Allium sativum*: A review

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Abstract

Nutraceutical foods furnishes the chances to ameliorate people health by lowering the cost of health care. Medicinal herbs are fortified with phytochemicals possessing pharmaceutical potentials with no side effect. *A. sativum* is among most extensively studied medicinal herbs of Allium family. In the past few decades, its bioactive chemical constituents have been analyzed for their therapeutical properties. It possesses antidiabetic, antimicrobial, antihyperglycemic, antitumor, hepatoprotective, platelets inhibitory and antithrombic activities. Allicin is most essential biological active compound discovered in *A. sativum*, that work synergistically with other phytoconstituents in prevention of various diseases. Present review explores some biological perspectives such as antidiabetic, antioxidant and antimicrobial potentials of *A. sativum*.

Key words: Pharmacetuical potential, Phytochemicals, *Allium sativum*, Allicin.

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1. Introduction

Plants and plant products have significance in human life. Human used plants as influential therapeutic agent until in the middle of 19th century. The ancient system comprised of herbal medicine usage and practices was inherited and changed over centuries [1]. These medicinal herbs provide an alternative to health care system in both developing and rural communities [2]. Medicinal services of plants involve uses of herbs and their extracts for prevention and treatment of different diseases [3]. Medicinal plants herbs are enriched with ingredients which are used in synthesis and development of drugs against various disease problems [4]. Herbal medicines demand is increasing in both developed as well as developing countries, reviving the interest of pharmaceutical companies in medicinal plants [5]. *Allium sativum* (garlic) is well recognized for its pharmaceutical potentials. Researches in field of pharmacology, physiology and immunonutrition have reported its importance against various diseases and recommended it as functional food. Recently, health beneficial properties of *A.sativum* and its organosulphur metabolites were evaluated and extracts preparations were found to be effective against various health problems [6].

In this article, we reviewed recent research reports conducted to evaluate various therapeutical potential of *A. sativum* and enlighten its significance in nutraceuticals. We reviewed antidiabetic, antimicrobial and antioxidant activities inclusive of bioactive compounds responsible for these characteristics.

2. History

A. sativum is famous for its medicinal services for more than thousands of years. Chinese used it as herbal medicine for three thousand years. Egyptians, Romans and Greeks also applied it for healings of wounds. In world war I and II, it was practised for its anseptic potentials [7]. The earliest reference known in history reporting the use of garlic as food comes from ancient Egyptians. Laboring class involved in building pyramids were particularly fed with *A. sativum* to provide strength and increase productivity [8]. In Greece during Olympics it was given to athletes before the start of competitions to enhance their performance [9]. Primarily *A.sativum* was consumed by lower class in history and was not favorite food of ruling classes. Moreover its entry in religious temples was strongly restricted due to characteristic pungent odor [8]. *A. sativum* was advised to abet digestion and respiration in ancient Chinese [10]. As it is a common spice it was recommended for daily consumption but in limited amount. It was frequently used by Chinese in combination therapy and to treat fatigue, insomnia, depression, sadness and headache [11].

3. Morphology and chemical composition

A. sativum belongs to Alliaceae family. Botanical name is derived from two different words "*All"* that is a celtic word meaning "burning" and "*sativum"* a latin word meaning "cultivated" [6]. It can grow easily to height of 1-2m plant [12]. Scapes are stem end structures having flower heads of plant and base is formed by small bubils. It has look of long gentle neck curving present at stem's upper

end and is about 60 cm high [13]. Bulb is underground part formed by cloves clusters [13]. Its leaves are long, blade shaped arranged in alternative pattern [13]. Chemical analysis shows highest concentration of sulphur compounds responsible for its pungent odour and therapeutic properties. Most important sulphur compunds are allin, allicin, ajoene, s-allylcystiene, diallyl trisulfides, vinyldithines, allylpropyl disulphides, s-allylmercaptocystein. Allinase, peroxidases, myrosinase and other enzymes are also present in it in addition to minerals, vitamins, carbohydrates and proteins [6, 14]. Allicin was reported for its antibiotic and antifungal activities [15]. For pharmaceutical usage, various products of *A.sativum* are expedited as juices, oils, liquid extracts, macerated and powdered forms [16, 17].

4. Antidiabetic Effect

Diabetes mellitus (DM) is metabolic disorder that is perceived as 7th cause of mortality in the world and affects nearly 100 million people yearly. According to an estimate there will increase of DM cases from 15 billion in 2003 to 30 billion by 2025 [18]. In developing communities, nutraceutical foods furnish the chances to ameliorate the health by lowering cost of health care. Due to this reason, functional foods based on plant sources are becoming prevalent for their therapeutic activities [19]. According to world health organization estimation, nearly about 80% people in the world relies on herbal medicines [20, 21, 23]. Medicinal plants have various mechanisms to lessen blood glucose level [23-25, 26]. Carbohydrates are major dietary constituents. These carbohydrates are hydrolzed into glucose by α -glucosidase and α-amylase enzymes [27]. Insulin and glucagon are notable hormones that maintain blood glucose level within narrow range. Glucagon drives liver glucose from hepatocytes into blood streams for energy demands [28]. In the bloodstream, blood glucose level is raised, activating the pancreatic β cells to produce insulin. An insulin molecule then bind the specific receptors present on cell surface facilitating glucose entry into cells that then utilizes the glucose to fulfill energy needs and blood glucose concentration is lowered. In diabetes insulin secretion and activity is altered and the entry of glucose into cells is restricted. Subsequent condition is referred as hyperglycemia. Insufficient usage of pancreatic insulin directs to unusual elevation in blood glucose level. As insulin production is inflated, glucose level in blood stream is greatly decreased inducing hypoglycemic problem [29]. Heredity, environmental and genetic factors play critical part in the diabetes development [30, 31]. Insulin injection and other hypoglycemic agents are used as effective drugs but possessed some side effects and are also not much effective in long term complications treatment. Due to these fallouts and increasing human knowledge about disease complications, demand for drugs with lessens or no side effect is enhanced [32]. An antidiabetic agent currently available includes sulfonylureas, alpha glucosidase inhibitors, biguanides and thiazolidinediones. These agents are not widely used because of their pathological adverse effects and secondary failures [33]. Some plant have enzyme inhibitory activities naturally and scientists worked for years to identify their active components. *A. sativum* is one of the medicinal herbs that have α-amylase inhibitory activity [34]. Bioactive compound allyl disulphide oxide in *A. sativum* reduces the blood glucose concentration [20]. Allicin is one of active chemical constiuent that raise the serum insulin level. It spares the insulin by effectively binding to SH groups reactions [7]. Ashraf *et al*., [35] stated that dislipdemia in diabetic pateint have short term relieveing effects after treatment with *A. sativum*. Similarly, ingestion of *A. sativum* for period of 12 weeks reduced fasting blood glucose levels in a study by Kumar *et al*. [36]. Although these antidiabetic effects may be concentration dependent [37]. Garlic extracts showed significant potential in reversing hyperglycemia, hypercholesterolemia and proteinuria [38, 39].

5. Antioxidant activity

Free radicals are pivotal part of metabolic system and aerobic life. These are produced in some cell mediated immune responses and respiration. A pool of free radical is created due to drugs usage, smoking, overeating and exposure to ultraviolet radiations. Human body, naturally adopted to maintain balance between free radicals and antioxidant production, scavenge these radicals and thus protected from their deleterious effects. Any imbalance between free radical formation and antioxidant activity result in various diseases like hypertension, alzheimer's disease, atherosclerosis, cancer, ischemic diseases, inflammatory condition and diabetes [40]. Reactive oxygen species (ROS) are cleavage intermediators of respiratory chain reaction in mitochondria that intensely damaged the biological molecules as protein, lipids and DNA [41]. These ROS are extremely unstable molecules having unpaired electrons. For stabilization, they take the electrons from neighboring molecules ensuing unstable chain reactions. Lipid membranes are impermeable to these ROS thus they remain compartmentalized in specific area of production within cells and some who crossed the barriers are amply damaging. Harmful effects include cellular destruction, mutation and various diseased problems as cardiovascular complications [42]. In cells the antioxidants are naturally present to restrain small quantity of free radicals. Naturally synthesized antioxidants are categorized into two large groups, enzymatic group involves catalase, glutathione peroxidase, superoxide dismutase, and non-enzymatic group embraces vitamins A, C, E. Endogenously synthesized free radical scavengers minimize the chances of cellular destruction [43]. The consumption of antioxidants as nutraceuticals and food additives has been remarkably admired due to their health beneficial effects. The biological influence of free radicals depends on their subcellular localization, chemical nature, synthesis and degradation rates [44]. Fruits, whole grains and vegetables are natural source of antioxidants. *A.sativum* is bedecked with phytochemicals possessing vivid antioxidant activities. Allicin is major bioactive compound present in freshly crushed garlic and produced from allin by allinase enzyme [45]. Capasso [46] observed that aged garlic extract exhibit antioxidant activity owing to the presence of stable organosulphur compounds such as allicin, diallylsulfites, diallyltrisulfites. Their antioxidants potentials comprised of free radicals removal and protection against mutational, cardiovascular and cellular destructive intricacies. In a study by Asdaq [2015], elevated levels of triacylglycerols, ALP, ALT, AST, total cholesterol, melanodialdehyde, oxidized glutathione, total glutathione, glutathione peroxidase reactivity in experimental rats were abated by garlic and s-

allylcystien (SAC) preparations. Total sulfhydryl, ferric reducing/oxidizing potential and superoxide dismutase, catalase activities in hepatocytes were increased [47]. However, free radical scavenging activity depends on polarity and nature of extracting solvent, isolation process, active compounds purity, along with testing system and substrate to be rescued by antioxidants [48].

6. Antimicrobial activity

Earliest known study on antimicrobial activities of *A. sativum* was done by Pasteur in 1858 [49]. *A. sativum* bioactive compounds inhibit the growth of fungi, protozoas, gram positive, acid-fast and gram negative bacterias including *Escherichia*, *Salmonella*, *Streptococcus*, *Staphylococcus*, *Klebsiella*, *Proteus and Helicobacter pylori* [50]. Although this activity of allicin was inhibited at high temperature due to denaturation [51] as allicin has extremely short half-life, but rapid and localized defense mechanisms [50]. Mode of action of allicin involves the complete or partial inhibition of RNA, DNA and protein synthesis [52]. Allicin has chemical interactions with various enzymes having thiol groups such as RNA polymerase, thioredoxin reductase and alcohol dehydrogenase [50]. Growth and development of microorganism will also stops because there will be no amino acids and proteins production. Cell wall phospholipid bilayer could not be correctly formed due to affected lipid biosynthesis in microbes [53].

Various protozan species such as *Opalina ranarum*, *Balantidium entozoon*, *Entamoeba histolytica*, *Trypanosomes*, *Leishmania*, *Leptomonas*, and *Crithidia* showed retarded growth in the presence of *A. sativum* extracts [54].

Bacteria are apparently unable to manifest resistance against *A. sativum* as its action strategy is entirely different from action of antibiotics [55]. Gulfarz *et al.* [56] observed that different solvent extracts of *A. sativum* proffered varying growth inhibition activities. Acetone extract of *A. sativum* exhibited best antimicrobial action whereas ethanol extracts was effective against *S. aureus*, *K. pneumineae*, *S. epidermidis*. But both acetone and ethanol extracts was not much influential against *E.coli*. Methanol extract exhibited potent antimicrobial activities against all tested microbes. In a review, Londhe *et al*. [7] stated that *A. sativum* has remarkable antifungal properties and is active against *C. albicans.* It possessed both fungicidal and fungistatic effects *in vitro* and *in vivo*. Crude garlic monopolized eminent antifungal potential. This is because of intricate chemistry of Allium species as diversity in processing bestows quite different products. Allicin thiosulfinates disappear on heat treatments and quickly transited to various other organosulphur derivatives [57]. So some of microbial growth inhibition activity may be lost on heating [58]. Suleiman and Abdallah [58] documented that *A. sativum* is best alternative medicine against fungal infections with little or no side effects than most of synthetic drugs. *A. sativum* damage the outer surface of fungal cells and weaken cell adhesion to epithelial membranes. Moreover, some of its organosulphur components interaction with enzymes that contain sulphur [59]. *A. sativum* juice has shown stronger inhibition potency against Trichophyton and Microsporum species, along with some dermatophytes, pathogenic molds and yeast [59-60].

8. Conclusions

Allium sativum is enriched with various flavonoids and phenolic compounds culpable for its pharmacological potentials. *A. sativum* is grown almost all over the world and also its various products have been developed and available in market in form of powder, oils, extracts and tablets etc. so rural and urban both communities procure it for daily diet supplements. It enhances insulin production and action, acting as hypoglycemic agent. Other therapeutic applications involved antimicrobial, antitumor, antithrombic and platelets inhibitory. Pharmaceutical industry now prefers the development of herbal medicines due to their easy availability, low cost and no side effects.

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