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Nutraceutical Properties of Garlic

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Introduction

Since ancient times there are various plants which are being used to heal diseases and adverse health conditions. One of such popular plant is garlic. The *Allium sativum* bulb belongs to the family of Lilliaceae formally known as Alliaceae and amongst the family, *Allium sativum* is the most popular food-herb used as condiment all over the world(Tijani *et al* 2019).Garlic contains compounds like allicin which increases immunity. Regulated and chronic intake of some functional foods or nutraceutical dietary supplements can help in reducing the risk of chronic lifestyle-related diseases. Amongst functional foods, garlic and its by-products stand out given their rich phytochemical profile. A comprehensive analytical approach is necessary to fully address garlic preparations health-promoting activities, considering the coexistence of several active ingredients from different chemical families (Ramirez *et al* 2021).Nutraceuticals are substances considered as food or components of food-imparting medicinal or health benefits encompassing prevention or management of diseases(Awan *et al* 2019).Several nutraceuticals have been identified that may help to prevent Neuroblastoma.

It has been found that two constituents of garlic, diallyl sulphide (DAS) and diallyl disulphide (DADS), can inhibit quorum sensing (QS) systems of *Pseudomonas aeruginosa*. For treatment of Diabetes mellitus 2, from the current therapeutic options, like insulin therapy and hypoglycaemic drugs, in recent years, attention has been shifting to the effects and properties that are still less or not known of medicinal plants as valid and inexpensive option with negligible side effects. Melino *et al* 2019 reported the relevant effects of medicinal plants and nutraceuticals in diabetes, particularly garlic. They mentioned that OSCs (Organo-

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sulphur compounds) derived from garlic (*Allium spp.*), can represent a valuable support to the diet in type 2 DM due to their properties. We find a lot of organo sulfur compounds (OSCs) in our bodies and the environment. Garlic, onion, shallot, leek, and chives are well-known representatives of the *Allium* genus (family *Amaryllidaceae*), that contain *S*-alk(en)yl-L-cysteine sulfoxides (Goncharov *et al* 2021). Alliin is the main organo sulfur compound in garlic and has also shown to induce a decrease in the expression of pro inflammatory cytokines, it can be used to cure obesity. Due to changing lifestyle, there have been various health disorders observed in recent years. A variety of lifestyle-related inequities can be mitigated with the aid of diet-based therapy. In this context, garlic is a powerhouse of nutraceuticals known to possess certain beneficial compounds, such as allicin, that are helpful in ameliorating numerous 236 physiological threats (Awan *et al* 2019).Tijani *et al* (2019) evaluated phytochemical, nutraceutical profiles and potential medicinal values of *Allium sativum* linn (Lilliaceae) on bacterial meningitis against bacterial meningitis pathogens (Tijani *et al* 2019).

Bioactive compounds in garlic

Phytochemicals compounds are secondary plant metabolites generally found in fruits and vegetables with non-nutrient physiologically functionality. There is an enormous range of phytochemicals that can be found in functional foods and dietary supplements. It includes phytosterols, carotenoids, phenolic compounds, phytoestrogens, organo-sulphur compounds, glucosinolates, and their degradation products, and dietary fiber (Quintin *et al* 2019).Garlic is considered as one of the highly bioactive natural sources that stands out from other foods. Several health-enhancing properties such as antioxidant properties, anticarcinogenic, antimicrobial, cardioprotective and others are accompanied with its consumption.These bioactivities are credited mainly to three photochemical families, fructans (mainly inulin), phenolic compounds (flavonoids), and organo sulfur compounds (OSCs) (Shang *et al* 2019).Most garlic studies have focused only on OSCs quantification in fresh garlic and galenic preparations (Ramirez *et al* 2017).Nonetheless, many other bioactive phytochemicals have been either ignored or partially investigated till now (for instance, some flavonoids present in garlic preparations).Cardelle *et al*(2015), Gu Figueroa *et al*(2015), Sultana and Anwar (2008) addressed insulin extraction and quantification, as well as the phenolic compounds content in garlic matrices, but most of the methodologies rely on outdated sample

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preparation techniques which are not only expensive but time-consuming and generally labour-intensive too. Moreover, in general terms, studies carried out on traditional garlic-based products have not considered a multi-phytochemical approach to fully report their health-promoting activities, which is due to synergistic effect of several active ingredients from different chemical families (El Sohaimy 2012). Therefore, updated and comprehensive methods for multi-analytes handling and measurement are needs of the hour. To enhance the overall yield and selectivity of multiple bioactive compounds environmental-friendly nonconventional methods, are suitable alternatives for analysis of natural product. To attain a high-throughput analysis of garlic-based products, Ramirez et al (2021) developed a multi-phytochemical protocol combining extractive techniques such as Ultrasound and Dispersive Liquid-Liquid Microextraction (DLLME), coupled to Liquid Chromatography with diode array detectors (DAD), for the determination of the main flavonoids, OSCs and inulin-type fructan, found in garlic preparations samples respectively. They successfully applied the proposed method to determine both polar and non-polar bioactive compounds content in different garlic preparations and therefore accomplishing the verification of the method suitability.

Fig. 1 Garlic field at vegetable farm of Dr. YSP UHF,

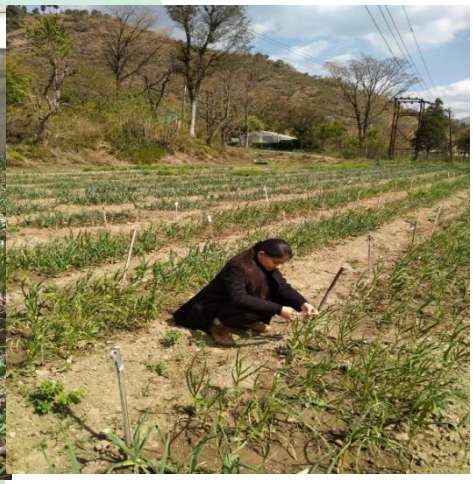

Fig. 2 Observing the garlic plants Nauni, Solan, HP

Role of garlic in disease prevention

Type 2 diabetes mellitus

Dietary therapy is considered as first step in treating Type 2 Diabetes Mellitus (DM). In India, it is a socially relevant chronic disease.It may lead to several vascular, macrovascular,

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and microvascular complications (cerebrovascular, coronary artery, and peripheral arterial diseases, retinopathy, neuropathy, and nephropathy), often accelerating the progression of atherosclerosis (Melino*et al* 2019). In particular, Melino *et al* 2019 paid attention to the organo sulphur compounds (OSCs) present in plant extracts that due to their antioxidant, hypoglycaemic, anti-inflammatory, and immune modulatory effects, can contribute as cardioprotective agents in type 2 DM. Moreover, garlic OSCs have a relevant characteristic to produce the gasotransmitter H2S.Indeed, a number of research have recently shown the pertinent impacts of endogenous and exogenous H2S in human diabetes mellitus, including through in vitro, in vivo, and clinical trials. Since ancient times, there are many herbal options being tried to treat DM (Evans W C 2009). More than 400 plantslike *Trigonella foenum greacum*, *Ocimum tenuiflorum*, *Opuntia spp.*, *Allium spp.*, etc. (Cefalu *et al* 2008, Ghorbani A 2013) and their compounds have been studied for type 2 DM treatment, and several reviews havementioned them too (Modak *et al* 2007, Marles and Farnsworth 1995, Ota and Ulrih 2017, Governa *et al* 2018).Among the nutraceuticals mentioned above, plant extracts with organo-sulphur compounds (OSC's) have raised curiosity the most. Several studies prove that OSCs and their different combinations inhibit insulin resistance and hyperglycaemia.

The family, Amaryllidaceae is characterized by the presence of OSCs with special properties. Allium genus produces S-alk(en)yl-l-cysteine sulfoxides. One of the most important glycaemic-controlled herbal medicines consisiting OSC's is garlic (*A. sativum* L.) (Cicero *et al* 2004, Thomson *et al* 2016).Even epidemiological and preclinical studies support the effects of OSCs from garlic extract as cardiovascular-protective agents (Iciek *et al* 2009, Dirsch *et al* 1998, Knowles and Milner 2000). Garlic shows wonderful results in DM, such as hypoglycaemia, hyperinsulinemia, hypotriglyceridaemia, anti-glycation, hypocholesterolemia, and anti-lipidperoxidation effects (Thomson *et al* 2016, Iciek *et al* 2009).Garlic is used either in dried or fresh form, and its derivatives show antihyperglycaemic effects in genetic animal models of DM (Thomson*et al* 2016) and clinically in humans (Ashraf *et al* 2011, Atkin *et al* 2016). Garlic has proved to improve insulin sensitivity (Padiya *et al* 2011).It's derivatives reduce both insulin resistance (Padiya *et al* 2013) and blood glucose in streptozotocin-induced and alloxan-induced mellitus in rats and

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mice (Sheela *et al* 1995, Lee *et al* 2013).These beneficial effects are due to the presence of OSCs which include derivatives from alliin and sulfoxide amino acids.

Neuroblastoma

Neuroblastoma (NB) is a highly malignant embryonic extracranial solid tumour that arises from sympathoadrenal neuroblasts of neural crest origin. Including genetic factors, there are maternal exposures to a variety of substances during pregnancy which are responsible for Neuroblastoma. Resveratrol, curcumin, and molecular components of garlic, together with certain vitamins may help to prevent NB development (Sbaffone *et al* 2022).Difficulties in treating advanced stage NB has resulted in the identification of several nutraceuticals and vitamins with potential to inhibit tumour activity (Zhai *et al* 2020), suggesting that dietary supplements with anticancer nutraceuticals and vitamins may not only improve cancer prevention, but also hamper progression. Sbaffone *et al* 2022 mentioned that nutraceuticals and vitamins that exhibit NB inhibitory activity, their mechanisms of action (pro-apoptosis, proliferation inhibiting, pro-differentiation, and chemotherapy efficacy promoting) and their potential use asdietary supplements for mother during pregnancy and breast-feeding in prevents the development, enhances spontaneous regression, and reduces early progression of foetal and neonatal NBs during pregnancy and breast feeding.Chopped or crushed garlic contain the non-proteinogenic amino acid alliin which is converted into allicin by the release of alliinase, and is then rapidly transformed into ajoene, diallyl sulphide (DAS), and diallyl disulphide (DADS) (Zhang *et al* 2020). Garlic also holds smaller amounts of biologically active g-glutamyl-S-allylcysteine (GSAC), S-methylcysteine sulfoxide (methiin), s-trans-1-propenylcysteine sulfoxide, and S-2-carboxypro-pylglutathione and S-allylcysteine (SAC) (Gao*et al* 2015). The allicin metabolite, DADS induces apoptosis of mitochondria and inhibits proliferation in SH-SY5Y NB cells (Filomeni *et al* 2003), and the pro-oxidant ROS producing activity of DADS also leads to cytoskeletal impairment, cell cycle arrest in G2/M, apoptosis, protein phosphatase 1 (PP1) activation, and subsequent Tau dephosphorylation (Aquilano *et al* 2010). DADS induced ROS production, however, also activates peroxisome proliferator-activated receptor gamma co-activator 1 alpha (PGC1α), which shows both cancer promoting and anti-cancer activity, and in NB cells encourages mitochondrial biogenesis with anti-apoptotic effects, consistent with potential of promoting NB(Pagliei *et al* 2013).

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Bacterial meningitis

Bacterial meningitis (BM) is a complication of malnutrition and a serious public health burden of high morbidity and mortality especially in different parts of world. The BM causes cellular haemorrhagic sepsis as well as metabolic, endocrine and neurologic disorders. Researchers have been giving immense attention to garlic for 4-5 decades for its nutraceuticals and medicinal properties with wonderful health benefits due presence of high quantity of organosulfur compounds. This burden of the disease is highest in the developing countries and especially in the immunity deprived rural populations (WHO 2007).*Allium sativum* extracts were found to express high antibacterial activities on *Escherichia coli*, *Helicobacter pyroli*, *Salmonella hadar*, *Neisseria meningitides*, *Streptococcus pnumoniae*, *Salmonella typhi* in which *E. coli* and *Salmonella typhi* are the most common cause of gastrointestinal infections (Derrida M 2003, Fattouch *et al* 2007). It has been found to contain certain active principles like allicin, allistatin, ajocine, allitridium, allixin, S-allylcysteine, diallyl disulphide, allylmethylsulphate, garlicin and scordinin which are of use in bacterial meningitis.

Summary

Garlic (*Allium sativum*) is one of the most important and well known pharmaceutical and industrial plants with numerous medicinal properties. It lowers blood pressure and cholesterol, fights against infectious diseases, prevents cancer, possesses anti-diabetic, antioxidant and anti-fungal properties. If cells are damaged, organo-sulphur compounds such as allicin (diallyl disulphide oxide) is produced enzymatically from alliin (S-2- propenyl-L-cysteine sulfoxide) of which garlic is a rich source.Above that, there are various bioactive compounds which have nutraceutical properties. Amongst functional foods, garlic and its by-products stand out due to their rich phytochemical profile. Numerous health-enhancing properties have been linked with its consumption, such as antioxidant properties, anti-carcinogenic, antimicrobial, cardioprotective, etc. These bioactivities are mainly attributed to three phytochemicals families, fructans (mainly inulin), phenolic compounds (flavonoids), and organosulfur compounds (OSCs) (Shang et al., 2019). Due to the above mentioned bioactive compounds, garlic has progressively acquired added value for its commercialization as a functional food. It has also appeared as an ideal raw material for phytotherapeutics

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manufacture. It is working as an excellent therapeutic in treating diseases like diabetes mellitus 2, bacterial meningitis, neuroblastoma, obesity etc. In this article, we will discuss various such properties which garlic withholds. Some are while others can prove beneficial to mankind in future.

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