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Medicinal properties of phytochemicals: A review

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Abstract

Phytochemistry is associated with the study of phytochemicals produced by the plants. Phytochemicals are often categorized as primary and secondary metabolites. Carbohydrates, lipids, proteins, nucleic acids are primary metabolite that means they are essential for the survival of the plants. Secondary metabolites are not pivotal for the survival of plants but determine their existence in the ecosystem. Phytochemicals present in plants possess varied bioactivities with abundant health advantages and have also been employed in conventional medicine system to treat a variety of ailments and diseases. In the present review therapeutic potential and brief mechanism of various classes of phytochemicals like polyphenols, flavanoids, saponins, cardiac glycosides, phytosterols and amino acids are discussed.

Keywords: Phytochemistry, Flavanoids, Saponins, Phytosterols, Cardiac glycosides

Introduction

Phytochemistry is the study of the investigation of phytochemicals produced by plants, their structural compositions, biosynthetic pathways, functions and mechanism of actions in the living systems^[1]. The chemical substances present in the plants often called phytochemicals are categorized on the basis of their structure and biosynthetic pathways as primary and secondary metabolites^[2]. Primary metabolites are highly cognate in their structural features. They are also vital for growth, metabolism, development and survival of plants. Proteins, carbohydrates, lipids and nucleic acid are the examples of primary metabolites^[3-5]. Lipids are responsible for regulation of cell metabolism and are pivotal for veracity of cells and organelles^[6]. Carbohydrates exhibit function as signaling molecules same as that of hormones and key components in source of energy and energy storage^[7]. Nucleic acid promotes synthesis of proteins and are transporters and storage components of genetic information^[8]. Secondary metabolites are not fundamental for the survival of plants but these components determine their interaction with surroundings and hence their existence in the ecosystem. Polyphenols, flavanoids, alkaloids, saponins, cardiac glycosides and anthocyanins are the examples of secondary metabolites. Phytochemicals are idiosyncratic to explicit plants and parts of plants. They shield plants from venomous agents such as insects, microbes and pathogens and events like extreme temperature and salinity. They are also responsible for imparting color to the plant^[9-11]. Plant based conventional medications are preferred over synthetic medicines due to its environment friendly properties and they are restraint of side effects. Phytochemicals are plant substances consisting varied bioactivities with abundant health advantages and have also been employed in conventional medicine system to treat a variety of ailments and diseases^[12-13]. Plants comprising of various bioactive phytochemicals possess diverse range of bioactivities like antioxidant, anticancer, analgesic, anti-microbial, anti-diarrheal, and so on^[14]. In the present review, therapeutic and medicinal properties of various phytochemicals namely polyphenols, flavanoids, saponins, cardiac glycosides, phytosterols and amino acids are discussed.

Medicinal Properties and therapeutic potential of phytochemicals

Polyphenols: Polyphenols acts as anti-oxidants in the human body and possess distinct biological characteristic such as antiviral, anti-diabetic, antifungal, antibacterial, anti-cancer, anti-inflammatory, osteoprotective, cardioprotective, antihypertensive, antiasthamic, neuroprotective, antiseptic, antiageing, cholesterol lowering and cerebrovascular protection. Dietary plant derived Polyphenols regulates carbohydrate and lipid metabolism, insulin secretion, β -cell functioning, stress signaling pathways and inflammatory processes. Green tea derived polyphenols epicatechin, epigallocatechin, epicatechin-3-gallate and epigallocatechin-3-gallate showed anti-cancer and chemo preventive effects in human prostate cancer.

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These compounds prevent tumor progression by influencing enzyme activities and signal transduction pathways. Stikic *et al.* showed anti-cancer potential of puno and titicaca quinoa seed extracts against the human colorectal cancer cell line HCT-16. Ferulic acid and ellagic acid were found to be the most abundant phenolic compound in quinoa seed extracts of puno and titicaca cultivars respectively. C.T. Kumarappan *et al.* demonstrated anti-oxidant activity of polyphenols extract of *Ichnocarpus frutescens* leaves. The free radical scavenging ability of polyphenols is due to their hydrogen donation ability resulting in suppression of free radical deterioration in the human body. Saravanan *et al.* revealed antioxidant, antimicrobial and antidiabetic activities of polyphenols of *Passiflora ligularis* fruit extracts. Phenolic compounds are potent inhibitors of α -glucosidase and α -amylase as well as stimulators of hyperglycemia and other diabetic complexities resulting from oxidative stress. Uniofin *et al.* evaluated anti-microbial and anti-oxidant activities of *Vernonia mespilifolia* less extracts enriched with polyphenols. Polyphenols possess ability to form complexes with metal ions, proteins and polysaccharides. As a result, they are responsible for suppression of microbial adhesion, hydrolytic enzymes and cell transport proteins. ET Bouhlali *et al.* exemplified anti-inflammatory activity of *Phoenix dactylifera L.* seed extracts consisting polyphenols. Protein denaturation is one of the several recognized reasons of anti-inflammatory ailments. Polyphenols enhance thermal stability of proteins and hence prevents their denaturation. Polyphenols modulates triglyceride levels and hence decrease the risk associated with cardiovascular ailments and atherosclerosis [14-23].

Flavanoids

Flavanoids possesses diverse cosmetic, pharmaceutical, nutraceutical and medicinal applications due to their antioxidant, antibacterial, anti-inflammatory, anti-viral, antimutagenic, cardioprotective, hepatoprotective, immune system strengthening traits and their ability to shield skin from ultra-violet radiation. Gwatidzo *et al.* demonstrated anti-oxidant activity of flavanoids present in *Carissa bispinosa*, *Ficus sycomorus* and *Grewia bicolor* fruits. Flavanoids restrain enzymes essential for generation of superoxide anion and reactive oxygen species such as xanthine oxidase, protein kinase, cyclooxygenase, lipoxygenase, microsomal monooxygenase, glutathione S-transferase, mitochondrial succinoxidase, and NADH oxidase. Flavanoids exert anti-microbial action by disruption of bacterial plasma membrane, formation of biofilms, prevention of cell envelope synthesis, suppression of nucleic acid synthesis, retardation of electron transport chain and adenosine triphosphate, formation of flavanoids-metal complexes and quashing of bacterial toxins. Wu *et al.* revealed antibacterial effect of flavanoid glabrol isolated from medicinal plant licorice against methicillin resistant *Staphylococcus aureus*. Glabrol is membrane active antibacterial agent and causes damage to bacterial cytoplasmic membrane of *Staphylococcus aureus* cells. The utility of flavanoids in the formulations of anti-wrinkle products is due their ability to quest reactive oxygen species which are principle source of wrinkles due to exposure of skin to ultra-violet radiation. Flavanoids impart protective and fumigating action to skin and subsidiary mechanical firmness to hair; they also possess rejuvenation and pigment extricating ability. Flavanoids modulates the rate of synthesis and release of nitric oxide which accounts for dissemination of inflammation and also reduces tissue congestion. Hence flavanoids possess antiedematous and anti-inflammatory

activity. Flavanoids acts as inhibitors of α -glucosidase and α -amylase and hence reduces carbohydrate digestion and glucose absorption. This lowers the increase in postprandial blood glucose levels resulting in anti-diabetic activity. Flavanoids posses' anti-platelets activity due their ability to inhibit platelet adhesion by modulating arachidonic acid metabolism and collagen metabolism [24-36].

Saponins

Saponins possesses vasoprotective, anti-inflammatory, expectorant, hypocholesterolemic, hypoglycemic, immunomodulatory, antifungal, antiparasitic, antitumor, anticarcinogenic, neuroprotective, hepatoprotective, anticoagulant, anti-bacterial and anti-allergic activities. Saponins reduces cholesterol levels in the blood and liver by producing insoluble complexes with cholesterol and bile acids. Saponins also act as a counteragent against severe lead poisoning. Saponins are eminent bioactive agents in antiageing cosmetic formulations and are also used as surfactants in personal care products like shampoos, baby care products, liquid soaps and dental creams. Saponins exert photo protective action against UV radiation by suppressing deterioration of extracellular matrix. Saponins exhibit synergistic action with existing antibiotics and hence may serves as plausible therapeutics to surmount multi-drug resistance in microbes. *Quillaja saponaria* saponins extracts are practically employed in food items and beverages due to their emulsifying and foaming traits. Saponins exert anti-inflammatory action by modulating production and liberation of pro anti-inflammatory agents. Saponins stabilize mast cells and declines allergic manifestation by stimulating deprivation of mast cells and histamine signaling. A disaccharide saponin diosgenyl β -D-galactopyranosyl-(1 \rightarrow 4)- β -D-glucopyranoside exerts anti-thrombotic activity by stimulating platelet conglomeration and plasma coagulation factor activities. Saponins impede cell growth and division of cancerous cells by interaction with its membrane cholesterol analogues. Saponin declines the risk of colon cancer by alleviating the formation of secondary bile acids. Saponins exert anti-diabetic activity by stimulating insulin secretion from pancreatic β cells [37-50].

Cardiac glycosides

Cardiac glycosides possess ability to cohere with discrete binding sites on sodium pump. Sodium pump regulates potent transport glucose and amino acids and restrain intercellular calcium levels. They exerts antiproliferative and apoptic effects on breast, renal adenocarcinoma, melanoma, prostate, neuroblastoma, leukaemia, pancreatic and lung cancer cell lines. Cardiac glycosides are potent regulators of angiogenesis promoting agent fibroblast growth factor-2. They are also known to restrain transcription factor NF- κ B that synchronize different gene expressions involved in apoptosis, inflammation and tumorigenesis. Bufalin, a cardiac glycoside containing a pyone ring at C-17 possess ability to regulate immune response and revoking of multi-drug resistance to chemotherapeutic substances in cancerous cells. Digoxin, a cardiac glycoside containing unsaturated lactone ring at C-17 enhanced lipid metabolism in streptozotocin induced hyperglycemic rats by stimulating calcium dependent, peroxisome proliferator activated receptor (PPAR δ) gene expression. Digitoxin evoke anti-inflammatory and vasoprotective traits by modulating phosphoinositide 3-kinase/serine threonine kinase signaling and Ca^{2+} /Calmodulin-dependent-protein kinase-II in endothelial cells

which reveals its foremost application in cardiovascular diseases like atherosclerosis. Digitoxigenin, a cardiac aglycone facilitates wound healing by promoting collagen fabrication in human dermal fibroblasts. Convallatoxin isolated from *Parquetina nigrescens* root bark demonstrated anti-hyperglycemic activity in streptozotocin induced diabetic rats [51-59].

Phytosterols

Phytosterols possess anti-inflammatory, anti-cancer, anti-diabetic, Anti-atherosclerotic, neuroactive, antihemolytic and antieryptotic properties. Beta-sitosterol exerts anti-inflammatory action by suppressing activation of P38, NF- κ B (nuclear factor - κ B) and ERK (extracellular signal regulated kinase) signaling pathways. Beta-sitosterol demonstrates anti-tumor activity by stimulating protein kinase C and sphingomyelin cycle pathways. Stigmasterol retrieved hyperglycemia by modulating insulin resistance resulting in enhanced GLUT4 expression and migration. Beta-sitosterol retards proliferation in human leukemia cells and promotes apoptosis by expedite activation of caspase-3. Phytosterols promotes reduction in cholesterol levels due to their ability to eject cholesterol from micelles producing unesterified cholesterol reducing its feasibility for absorption. Bio-cosmetics comprising of phytosterols moisturizing, anti-aging, rejuvenating and softening effects to skin. Stigmasterol exerts thyroid lowering and hypoglycemic traits by stimulating the activity of glucose-6-phosphate. Beta-sitosterol ameliorate short term memory, locomotor disabilities and cognitive deficits associated with Alzheimer's disease by restraining enzymes involved in metabolism of cholinesterases [60-70].

Amino acids

Amino acids are categorized essential and non-essential amino acids on the basis their constraint from the diet for nitrogen balance or growth. Essential amino acids are those whose carbon skeletons cannot be synthesized or are insufficiently assembled de novo in the body and hence must be supplied through dietary protein to overcome its necessity. Phenylalanine, valine, tryptophan, threonine, isoleucine, methionine, histidine, leucine and lysine are recognized as essential amino acids for the humans. Non-essential amino acids are those which are synthesized de novo in the body in appropriate quantity to compensate its need. Alanine, tyrosine, serine, aspartate, proline, asparagine, glycine, arginine, glutamate, cysteine and glutamine are identified as non-essential amino acids for humans. Amino acids are fundamental entities for protein synthesis in cellular metabolism. They regulate biosynthesis of nucleotides, lipids, glutathione, glucoseamine and polyamines and are also involved in various physiological processes like skeletal muscle functioning, cell signaling, gene expression and homeostasis regulation. Glycine acts as precursor for synthesis of RNA and DNA, regulates Ca absorption in the body and also boost immune responses. Leucine, a branched chain amino acid, is effective stimulator of insulin secretion. Threonine enhances the production of antibodies in lymphocytes. Methionine is involved in the metabolism of polyamines, creatine and phosphatidylcholine and recycling of sulphur ingested in energy depleting reactions. Tryptophan participates in protein synthesis, serotonin synthesis and kynurenine synthesis. Through serotonin synthesis, it regulates endocrine system, cortisol, growth hormone and prolactin [71-82].

Conclusion

Plants comprising of different bioactive phytoconstituents possess antioxidant, anticancer, analgesic, anti-microbial, anti-diarrheal, and so on. Flavanoids exhibits antioxidant, antibacterial, anti-inflammatory, anti-viral, antimutagenic, cardioprotective and hepatoprotective traits. Amino acids stimulates the regulation of biosynthesis of nucleotides, lipids, glutathione, glucoseamine and polyamines and are also involved in various physiological processes like skeletal muscle functioning, cell signaling, gene expression and homeostasis regulation. Polyphenols modulates carbohydrate and lipid metabolism, insulin secretion, β -cell functioning, stress signaling pathways and inflammatory processes. Hence these bioactive phytochemicals can serve as optimistic therapeutic agents as individual entity or enhance potential of existing pharmaceutical drugs.

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