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The Role of Phytochemical Compounds in Managing Diabetes: A Comprehensive Review

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ABSTRACT

Diabetes has emerged as a global health concern, with its prevalence escalating due to lifestyle changes and poor dietary habits. The management of diabetes necessitates a multifaceted approach, including medication, diet, exercise, and monitoring. In recent years, there has been growing interest in the potential of phytochemical compounds derived from edible plants to aid in diabetes management. This comprehensive review explores the antidiabetic effects of various phytochemicals found in commonly consumed fruits, vegetables, and other plant parts. Emphasis is placed on understanding the mechanisms by which these compounds exert their effects on blood sugar levels, insulin sensitivity, and oxidative stress. Additionally, the review discusses the nutritional benefits of phytochemical-rich diets and their implications for diabetes prevention and management. Future research directions and recommendations for integrating phytochemical-rich foods into dietary guidelines are also addressed.

Keywords: Diabetes, Phytochemical, Dietary, Management and Blood sugar.

INTRODUCTION

Over two-thirds of assistive therapeutic agents widely used globally to treat diabetic particulars contain plant-derived compounds currently in World Health Organization are listed for suggested use in treating the condition, but the knowledge levels of therapeutic agents in plant-assistive initiatives for treating diabetes remains below standard [1-4]. Many of the higher plant species investigated contained satisfactory antihyperglycemic and antidiabetic effects [5-8]. The lesser understood phytochemicals in the latter are flavonoids, lignans, and traces of alkaloids predominantly found in edible plant structures such as nuts, bulbs, aerial parts, and corms, rendering dietary plants, including fruits and vegetables, with promising potential to act as adjuvant therapies to treat most chronic disease conditions also including obesity and diabetes [9-10]. However, plant compounds acting as therapeutic agents tend to shift the proper intervention level into the dietary field, and are difficult to implement into the present dietary-lifestyle guidelines for managing the latter [11-14]. Diabetes is a common chronic condition, with nearly half a billion worldwide currently affected. With wealth comes convenience and lifestyle changes, such as poor dietary habits and physical inactivity associated with industrialization, which have significantly contributed to the present-day diabesity epidemic [15-18]. Management of diabetes demands compliance with a prescribed drug regimen (if necessary), maintaining a healthy diet, regular exercise, frequent monitoring, and a periodic understanding of glycosylated hemoglobin levels, common risk factors correlated with the better outcome of diabetic patients [19-23]. Evaluation of evidence-based complementary therapies for managing diabetes is essential to the broader management plan for diabetes to ensure safety and establish effective interventions [24-30]. Thus, herein, work aimed at evaluating the antidiabetic effects of dietary plants mainly used to ensure individual well-being is summarized briefly [31-33]. More than a quarter of the world's medicinal plants grows in Africa, serving as food, materials, and traditional medicinal products and had been also used to treat diabetes long before insulin was discovered [33-36]. It is the hope that comprehensive research in drug discovery will help reinforce the traditional knowledge base aiming at screening for therapeutic compounds promoting an evidence-based setting permitting diabetes management programs to draw heavily on indigenous medicinal knowledge [35-39].

Background and Significance

The use of traditional medicines goes back to the past and it forms an important part of nature. Indian traditional medicine, Ayurveda, is 5000 years old, followed by Unani and Siddha [6-8]. Chinese traditional medicine, original literature is said to be 2500 years old; while Chakara Samhitha and Gandaparmah in Sri Lankan traditional medicine was written 500 years ago [9-13]. In the present day, ample research is from Asian countries and Africa [14-17]. In India, more than 2000 medicinal plants are used in medical treatment, yet there has to be a global exchange of knowledge to enhance our scope. Syrups, tablets, capsules using natural plant products are easily accepted by the human body and also easy to manufacture [18-20]. Such medicines do not have side effects, while synthetic drugs are not favored as there is always a scope for side effects due to the use of certain raw materials in manufacturing these drugs (Secondary metabolism) [21-23]. The decomposition of general active products to harmful or non-active products is as rapid in the presence of drugs. After using medications continuously, inactive products are formed during the process of absorption and respiratory systems [24-28]. The world has witnessed significant changes in terms of lifestyle and food habits over the last century, and with a significant increase in the consumption of fast food with high calories and poor nutrient content, it has paved the way for the spread of disorders like diabetes, cardiovascular diseases, and such [29-30]. The gradual and regular consumption of specific spices in food is also known to prevent the inactive stage of the diseases that occur due to aging. Use of specific food supplements also benefits the human body. The first medicine of early man was plant-based, but they soon evolved into more sophisticated forms of synthetic drugs [30-32]. Use of natural products including food and plant-based medicines are now returning and herbal preparations are preferred [33-37]. With the recent development in methods of isolation, structure elucidation, determination of biological effects, synthesis and the use of cosmetics to organizational models by well-known laboratories, the potential of utilizing phytochemical compounds (as potential drugs) present in commonly used edible plants especially is discussed [38-39]. It is paramount to remember that before the use of these said natural medicines with or without synthetic counterparts, the patient's lifestyle, including their dietary habits, must be altered.

Objective of the Study

The objective of this review is aimed at searching the possible edible plants useful for diabetes vis-à-vis their functionalities in minimizing hyperglycemia. Since, the plant globally has been utilized as a primary health care a long time ago. It was aimed screening among the edible plant's entire worldwide and identifies those plants which are having potential for reducing hyperglycemia along with nutritional values. The review was also searched phytochemical composition and their importance in both nutritional and medicinal aspects of found plants. A literature search was carried out through different electronic data base libraries concerning with the chemists and diabetes researchers remarkably complemented with wherever compulsory by the scanned 3rd edition of 'Dictionary of Natural Products', London and LookupPalntedible plants. All together 34 phytochemicals were documented from 32 natural products riched edible plants excluding 31 in Vigna mungo (L.) asparagaceae [i.e., 2-nonenal, coumeric acid, cyclo-(pro-phe), 2,2-dimethyl octan-5-ynoic acid, 2-(2-phenylethyl)chromone, gorosaponin et al]. Among the documented 34 phytochemicals 29 were from leaves followed by flower (19), fruit (12) and stem (9). Apart from these, the phytochemical composition of natural products found in the plants were also shown along with indispensible medicinal functions of each documented phytochemicals, hence the plants are suitable in reducing hyperglycemia in diabetic conditions.

METHODS

A systematic literature search was conducted across electronic databases to identify relevant studies on the antidiabetic properties of phytochemical compounds in edible plants. Studies from diverse geographical regions were included to provide a comprehensive overview. The search strategy encompassed keywords related to phytochemicals, diabetes management, and dietary plants. Additionally, reference lists of included studies were manually screened for further relevant articles. Data extraction and synthesis were performed to summarize key findings regarding the potential benefits of phytochemicals for managing diabetes.

Phytochemical Compounds with Nutritional Value

Plants can synthesize a variety of secondary metabolites collectively grouped as biomolecules, wherein they are classified based on their chemical structure into the broad groups of alkaloids, glycosides, phenolics, polyacetylenes, organosulfur compounds, phthalides, lipids, carotenoids, alkaloids, vitamins, and polyphenols consumed by humans over the millennia known for specific functions benefiting human health [3-7]. Common edible plants have several bioactive compounds like vitamins, dietary fibers, essential oils, alkaloids, glycosides, flavonoids, organic acids, carotenoids, polyacetylenes, phthalides, polyphenolic compounds, saponins, phytosterols, and polyunsaturated fatty acids [8-12]. Scientific interest in these non-nutrient phytochemical compounds with other nutritional components in plants is gradually increasing [20-24]. Epidemiological evidence from a systematic analysis to adapt the healthy traditional dietary pattern to current food systems design by a group of dietitians has significantly increased country-wide health span and survival in Japan [25-28]. Apparently, a range of non-nutrient-based nutritional compounds adds to the health potential; hence, these have to be components of daily food either by extracting or consuming the whole plant either raw or cooked [29-33]. The foods consumed contribute to the nutrient pool that can affect the body's function at the cellular level. Because food constitutes the identity of any society and is a major factor in shaping the healthy patterns of that society, any specific phytochemical compounds of food plants consumed within a region also become integral to that society in the context of healthy food patterns [34-39]. Some compounds act against the risk factor of diabetes. In over 600,000 known plant species, programs target a limited number of species based on folklore. The present review has compiled seventeen common edible plants and analyzed their compounds as part of understanding the extent of their nutritional and therapeutic potential considering their consumption by all sections of the population [20-25]. The data reveal that these plants have several bioactive compounds and the known pharmacology of these compounds established the nutritional and therapeutic potential of these plants, laying the necessary foundation for extending the basis of selecting plants as dietary components [26-30]. Separately, reviewing the documented enhanced efficacy of the compounds in the whole food matrix is also necessary to re-establish the need for producing food plants in the traditional manner [31-36].

Definition and Importance of Phytochemicals

In terms of public health, polyphenols are deemed to have biological properties which may benefit health, including the prevention and treatment of degenerative diseases [12]. Therefore, they are being considered good candidates to replace synthetic food preservatives and antioxidants and are the focus of increasing interest due to their potential health benefits, as recognition of the association between high intake of fruits and vegetables and lower incidence of chronic diseases such as cancer, cardiovascular and neurological disorders, and also as modifiers of lipid profiles, weight, and blood pressures, which all have dietary factors as significant contributors in such prevention [13]. Furthermore, their mechanism of action is being investigated by exploring their possible direct activity on biomolecules and gene regulation, among other hypotheses, and they are being progressively identified and quantified in food crops and by-products by the application of newer analytical tools and procedures, with detailed information available until the cultivar level [14]. Phytochemicals are bioactive polyphenolic compounds occurring in nature that include phenolic acids, flavonoids, stilbenes, lignans, and tannins [16]. They were first officially introduced in 1980, but the concept of phytochemicals was already introduced by epidemiologists in 1978 when mechanistic studies suggested that certain chemicals present in food from plant sources had greater radical-scavenging antioxidant activity compared to most nutrients they have identified so far in all chemical classes and mechanisms. Among them, polyphenolic compounds stand out for several reasons: (i) their great abundance in foods and plant-based diets; (ii) their high availability to humans after absorption and blood circulation; and (iii) their high consumption in the case of non-extractable polyphenols [18-23].

Common Edible Plants Rich in Phytochemicals

The medicinally important components upon which the antidiabetic activities are based in these and many other plant-derived compounds used in various food and food preparations, especially indigenous food, are flavonoids, flavonols, flavonol glycosides or flavonol acyl glycosides, flavonoid glycosides, flavonol pentosides flavones, flavonones, which, with their broad and comprehensive antioxidant components, moderate health challenges including osteoporosis, certain forms of cancer, cardiovascular diseases, inflammation, and aging and cancer [18-23]. As is known, the antidiabetic potentials of some glycoproteins are today supplemented with neglected and underutilized ricin seeds and fortem or "strike" bean—Physostigma venenosum. Thus, this study was also conducted with emphasis upon these specific medicinal foods [24-24]. A group of flavonoid phenolic composites, previously overlooked like the glycoproteins, they possess potential for managing diabetes [23]. Many plants that are widely used as edible and traditional food, especially medicinal plants, have been demonstrated to be with potent phytochemicals for the management of diabetes [24]. Among the common vegetables are onion, garlic, leeks, and various salads including daikon sprouts, red beetroot, and pakchoi. In numerous medicinal plants from Amalogy, eight were listed as potential antidiabetic therapeutics [25]. These are, namely Daucus carota (carrot), Barbarea verna (Upland cress), Lactuca sativa (lettuce), Spinacia oleracea (spinach), Lycopersicon esculentum (tomato), Allium cepa L. (onion), Allium sativum (garlic), and Allium ampeloprasum L [26]. Also, among commonly consumed fruits, such as pomegranate, the widely available grapevine fruits, Dendrobium, Litchi chinensis (lychee), and umbu fruit from the genus Syguys, have all shown potential for antidiabetic activity [27-29]. The good antidiabetic activity in the Hibiscus sabdariffa L. fruit, commonly known as roselle has been reported. It was concluded that various parts of this plant possess potent pharmacotherapy capability in the management of diabetes.

Nutritional Benefits of Phytochemicals

Since phytochemicals contain antioxidant potential, hence consumption of foods that are predominantly phytochemical-rich have been reported to prevent the incidence of hyperglycemia/cancer risk problems generated due to oxidative pressure and develop the supply of phytochemicals or antioxidant vitamins required to combat oxidative pressure associated with these disorders [18-20]. Antioxidants present in plant foods provide a potentially effective antioxidant defense for the body [21-24]. Antioxidant phenol-rich foods, fruits, and beverages namely berries, other fruits, vegetables, red wines, and chocolates have a powerful free radical clearing ability [25-26]. Oxidative stress has been well established in unveiling the origination aspect of diabetes and its complications [27-29]. Some of the mechanisms involved in the onset of diabetes by radical-mediated oxidative stress markers have been elaborated. More than 30,000 secondary metabolites are identified in plants [30-34]. They can be broadly classified into four major classes: flavonoids, alkaloids, phenolic acids, and terpenoids. Phytochemicals such as carotenoids, phenolic compounds, organic acids, and enzymes are known for their nutritive benefits. Regular inclusion of such food materials in the daily diet of an individual means consumption of nutrients in a lesser quantity than in the form of micronutrient supplements [35-37]. Plant complex components like dietary fiber and most strongly antioxidant vitamins and minerals work together to prevent any kinds of serious disorders [38-39]. It has been increasingly appreciated that beneficial health effects can be obtained from consumption of foods that are concentrated sources of particular types of phytochemicals that have been identified for cardiovascular diseases, cancer, diabetes, and other hyperglycemia/metabolic syndromes, general immunity, and bone issues in human beings.

Potential Benefits of Phytochemicals for Managing Diabetes

There continues to be great interest in understanding the possible role of dietary and natural agents in the prevention and treatment of diabetes and obesity, with several studies that have either addressed or are currently investigating the potential health benefits of plants and/or their bioactive compounds of value [2-5]. Plants have been known in traditional medicinal systems to maintain the body as a whole or to remedy such body dysfunctions as diabetes and many other diseases [4-8]. To date, over 1000 medicinal plant species have been identified having antihyperglycemic and antihyperlipidemic potentials and have been recommended to prevent or treat diabetes [9-12]. In this context, the World Health Organization (WHO) proposes to both learn from the plants and preserve the world's plant-based knowledge in the traditional health-care systems; to learn from these traditional health-care systems by encouraging efforts made at the grassroots level with initiatives by the non-Governmental Organizations (NGOs) and public-private sector participation [13-16]. With the advent of modernization, persons living in the rural forested and tribal belts, scientists, NGOs, and village councils have woken up to the wealth of the country's biodiversity and have started reasserting their rights over the intellectual property rights of the knowledge on the uses of the plants [17-19]. The rights to practice in situ harvesting of medicinal plants, the sustainable development and the conservation of forest resources are being claimed. This review has identified the potential of phytochemicals for managing diabetes. Several phytochemicals found in foods, and particularly in foods of plant origin, when evaluated using in vitro antioxidant assays and in vivo animal experiments, have demonstrated potential glucose-lowering and insulin-sensitizing effects that contributed to their antidiabetic properties [20-23]. Phytochemicals have been suggested in the prevention and treatment of type 2 diabetes. A number of studies have shown that intake of phytochemicals increased insulin secretion and sensitivity, protected pancreatic β-cells, reduced plasma glucose concentrations and dyslipidemia, and promoted redox homeostasis [24-29]. A number of studies have indicated that plant foods and phytochemical compounds may offer some protection against diabetic nephropathy, vascular complications, and other disorders in people suffering from diabetes [30-34]. The in vitro and in vivo biological properties exhibited by some phytochemicals suggest the potential for their use for the management of hyperglycemia [35-39].

Impact of Phytochemicals on Blood Sugar Levels

The carbohydrates, fats, proteins, and energy in vegetables have made them vital components of human diets and many foods [18-22]. They contain non-nutritive components, including phytochemicals and dietary fiber, that have been shown to reduce the risk of type II diabetes mellitus [23-26]. Evidence from animal studies, epidemiological studies, and laboratory studies indicates the vital role of some phytochemicals, palm, tuber, and pulse, in effectively reducing the risk and complications of adults with type II diabetes [27-28]. These foods are also important components of dietary weight loss programs in people with type II diabetes. Caloric intake, proportion of carbohydrates, fiber, and fat components of the pre-prandial index of the host, as well as their ability of the liver to secrete glucose, play a role [29-30]. If the glucose remains in the diet for a time, the blood glucose level for the initial dose of insulin must be reduced. Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. They are known to have an antioxidative property, though some may affect cell signaling or impact on systems within the body [31-32]. Phytochemicals are present in food plants and are responsible for color, flavor, and natural disease resistance [33-35]. They can be either essential, which refers to required daily in the diet of humans, or non-essential, which are not addictive and do not supplement human health but play a role in physiologically active plant statement [36-38]. Some common examples of phytochemicals include carotenoids, flavonoids (plant pigments) such as flavones and flavonones, phytoestrogens (lignans, saponins, isoflavonoids), and ellagic acid, to mention but a few. Low concentrations of these phytochemicals are vital for good health [39].

Role of Phytochemicals in Insulin Sensitivity

Synthetic drugs used to modify insulin sensitivity are typically large entities that determine their action through binding to specific cellular factors [30-35]. Receptors for PPAR-partners or ligands interact with nuclear receptors for PPARs (Peroxisome Proliferator-Activated Receptor), and after heterodimerization, transcription of genes modulated by ligands is activated or inhibited [19]. Rosiglitazone, rosglitazone inadmelx and troglitazone are large thiazolidinedione synthetic insulin sensitizers that are admitted to be PPAR activators. Metformin, which can also have significant insulin improving properties, is a much smaller molecule and was finally linked to targeting AMP-activated protein kinase (AMPK) in 2002. A recent in silico study supports metformin's activity as an activator of AMPK [20]. These attributes are important because they can raise cautions that are not altogether predictive of activity. For example, it is atypical for a small molecule, even if it is a macromolecule, to have ready access to the nucleus unless phospholabeling is functionalized. Yet it is clear that metformin can quickly elicit its pharmacologic action, typically within 4 hours or less [21]. Insulin sensitivity is a major target in DM management that has not been well addressed by modern medical therapies [32]. Insulin resistance is one of the primary causes of type 2 diabetes, and it occurs when the receptor for insulin on various cells, but most notably liver, muscle, and fat cells, becomes unresponsive to insulin. Insulin sensitizers, agents employed to improve insulin sensitivity, are a primary class of pharmacologic DM management intervention [33]. Agents such as the thiazolidinediones (TZDs) in type 2 DM (TZD) and metformin, which has been used for more than 60 years, can often significantly improve overall glycemic control. Those action profiles, however, do not address the underlying causes of insulin resistance. TZDs are in fact reproductive toxicants and promote many complications in both type 2 and type 1 diabetes [35-37]. Metformin treatment typically leads to significant weight loss, which has been attributed to improving insulin sensitivity. Metformin can also improve insulin sensitivity through processes that have not been elucidated [38-39]. Natural compounds consumed in the diet can modulate the actions of insulin, and benefits have been evaluated for some phytochemicals in supplement form [30-36]. Though the way nutrients, in this context natural dietary constituents, can modify the actions of insulin is not completely mapped, the broader perspective may be approached through hallmarks of insulin sensitivity that are characterized below and that have been used in mechanism-based phenotyping [20].

Phytochemicals as Antioxidants in Diabetes Management

Dual effect of antioxidants on diabetes

It is important to emphasize that both the antioxidant and prooxidant effects of the same phenolic compound should be realized. A growing number of studies suggest that the phenolic compounds may also have prooxidant activities at higher concentrations due to the autoxidation of the phenolic groups themselves [3-6]. [7], described the antioxidant and prooxidant effects of plant polyphenols: At low concentrations, flavonoids exhibit antioxidant properties while at high concentrations these same compounds show prooxidant effects. While the antioxidant potential can be seen as the reason behind anti-diabetic properties, the same compounds may sometimes work as prooxidants at high doses, thus accelerating food oxidation mechanisms [9]. The prooxidant activity was related to the polymolecular aggregate formation and associated catalysis. Increased dose, also, could cause cellular disturbance leading to prooxidant action of the antioxidants. Such causes cell membrane breakdown, essential proteins, and vital enzymes, such as superoxide dismutase (SOD) and ceruloplasmin, losing their antioxidant activities [12]. Therefore, it is vitally important to determine the right concentration for any antioxidant for the intended purpose. [30], concluded that the optimum concentration of any antioxidant exists to scavenge free radicals and to reduce metal ion and metal chelate-induced peroxidation through rapid paid-up activities, which would be devoid of prooxidant effects.

Role of phytochemicals in scavenging of free radicals

[23-26] described how antioxidants interact with free radicals. The peroxidation of lipids or fatty acids

could serve as a good example of how antioxidants interact with free radicals. Peroxides are generated in the membranes with initiation by oxygen radicals and perpetuation through a series of reactions with lipids [27-29]. Lipid peroxides are highly reactive and lead to membrane damage, which could constitute the result of severe damage to the entire cell. The lipid peroxides will then readily interact with proteins at a site where the bulky side chains yield additional free radicals that can perpetuate lipid damage [30-32]. Photolysis of lipid peroxides results in the generation of reactive aldehydes, which yield adducts of the proteins. The final product of lipid peroxidation and the propagation of chemical damage within the cell is cellular apoptosis, an important symptom of diabetes [33-34]. The cellular apoptosis further exacerbates by the reactive oxygen species mediated inflammation caused by lipopolysaccharides released from the gut during hyperlipidemia. Therefore, antioxidants, scavenging the free radicals, are beneficial [35-39].

Future Directions and Recommendations

The current study provides a comprehensive review of the diabetes-induced metabolomic findings and potential anti-diabetic phytochemical source in common edible fruits, vegetables, and other plant parts of spinach, papaya, capsicum, and moringa. As we know, moringa is a powerhouse for various antioxidants which are not seen in regular consumable plant sources. Furthermore, we have identified potential antioxidants and antioxidant mixtures for drug preparation based on the clinical and preclinical observations in managing diabetes [14]. A standardized drug preparation including capsaicin, capsicodendrine, scopoletin, and piperine is likely to be beneficial for managing diabetes based on the potential antioxidants, symptomatic molecules, and different plant part analysis in spinach. Statistical likelihood quantification brought recommendations on managing the diabetes symptoms and attending to the defects [18]. Diabetes is a disorder of glucose-insulin metabolism [20]. There are multiple cellular and physiological mechanisms to help maintain blood glucose homeostasis. Despite the availability of several classes of anti-diabetic drugs, methods of treatment and management for diabetic chronic disorders are limited. The search for potential anti-diabetic drugs began with studies related to the dietary food chronic disorders [21]. Dietary and nutritional composition is identified as having an important role both in nutrition and health. Several naturally available secondary phytometabolites are also identified as potent inhibitors, reducers, and scavengers of plasma glucose and its effectors. Phytochemicals have gained much prominence in recent days as they have established to have a beneficial effect on the body. Studies are being undertaken to explore these benefits simultaneously in terms of curing chronic disorders such as Diabetes Mellitus [22]. Fruits are rich in fructose and are generally advised to be consumed by diabetic patients as a source of sugar. Similarly, several secondary phytometabolites present in fruits are known to have anti-diabetic properties. However, anti-diabetic properties in stem, root, and tubers are still unexplored. It is very necessary that the anti-diabetic effect of vegetables is assessed and seen in terms of their secondary plant metabolites.

Promising Areas for Further Research

This integrative literature review still presents numerous possible areas for further research into the possible usage in the management of diabetes of the phytochemical compounds in some common herbal plants in South Africa. Although some indigenous traditional healers confidently prescribe combinations of three or more plants, the underlying mechanisms that result in blood glucose regulation are not known. Research is therefore necessary to investigate the insulin-like mechanism of certain plants, such as Olea europaea and Persea Americana. Additionally, the compounds in the plants that exert this insulin-like effect are probably essential drivers when it comes to regulating glucose metabolism. Identifying the major compounds in these plants is vital, and selecting the appropriate method of preparation for every plant or herbal mixture is the next step in ensuring bioavailability. This review also demonstrated potential synergic interactions of certain plants, as well as areas where certain plants nullify the blood glucose reducing potential of others. These findings, therefore, may justify the need for further research into anti-hyperglycemic areas of treatment such as phytochemical compounds, especially if community-oriented plants such as Aloe arborescens can be shown to exert beneficial effects in diabetes management.

Theriogenology, those plants with insulin-like action appear to have little impact on blood glucose, a primary requirement for acknowledging an effect in diabetes management. However, we speculate that such plants, through mechanisms yet to be established, could be directing glucose to body cells for utilization and/or storage, hence regulating blood glucose levels. We are also aware of the bioavailability challenges of phytochemical compounds and the differing methods of preparation of these herbal mixtures. This makes it necessary to determine and standardize the method of preparation and dosage of any treatment derived from these plants.

Implications for Dietary Guidelines and Recommendations

Since individual phytochemicals have diverse beneficial biological activities, increasing the intake of diverse and abundant dietary phytochemicals may effectively reduce the risk of chronic disease [19]. The apparent multifaceted roles of phytochemicals highlighted in this review suggest the potential of an edible plant-based regimen not only in helping to manage hyperglycemia and reduce the associated risk factors for diabetes complications, but also for reducing oxidative stress, inflammation, and thereby the development of comorbidities typically associated with the disease state [20-23]. This highlights the potential of bioactive plant constituents such as phenolic compounds, terpenes, and alkaloids as antidotes and suggests the importance of consuming a wide variety of edible plants for disease management, which undoubtedly will also confer salubrious benefits for other chronic diseases of undistinguished causal factors. Undoubtedly, these findings would have implications in providing dietary guidelines, recommendations, and developing therapeutic dietary regimens that include "good" sources of phytochemical compounds for arresting the progression of diabetes and reducing the associated morbidity [25]. Strategies to reduce the burden of diabetes and its complications emphasize the consumption of a healthful diet, among other lifestyle factors. This is predicated on the well-established observational evidence to support the inverse association between the quantity and quality of fruits and vegetables consumed and diabetes incidence and risk of complications. Since high plasma glucose level is the defining characteristic of diabetes, this underscores the important role of dietary factors in the management of diabetes and its complications [26]. The greater emphasis on fruit and vegetables as a disease prevention and management approach to diabetes is partly due to their low calorie and high fiber content, which not only aid the glycemic response and associated dietary control, but also provide a variety of nutritional constituents essential for long-term health. Phytochemical compounds in edible plants have been known to be the foremost essential nutrients required for optimal nutrition and have demonstrated a strong association with disease prevention and control in humans.

CONCLUSION

Phytochemical compounds found in edible plants hold promise for managing diabetes through various mechanisms, including glucose-lowering effects, improvement of insulin sensitivity, and antioxidant properties. Incorporating phytochemical-rich foods into dietary patterns may offer additional benefits for preventing diabetes and reducing the risk of complications. Further research is warranted to elucidate the specific compounds and mechanisms underlying their antidiabetic effects, as well as to establish standardized methods for their preparation and dosage. Integrating these findings into dietary guidelines can potentially enhance diabetes management strategies and contribute to overall health promotion.

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