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BIOACTIVE POTENTIAL OF AMARANTHUS HYBRIDUS LEAF EXTRACTS ANTIOXIDANT AND ANTIDIABETIC ACTIVITIES

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Abstract

Amaranthus hybridus is a leafy vegetable with high nutrition value and use as medicine. The objective of this research project was to test samples made from leaves of amaranth for their ability to scavenge free radicals (antioxidant activity) and their effect on blood sugar levels (anti-diabetic activity). Leaf samples were collected and prepared (dried, ground) and then extracted using various solvents. Antioxidant activity was determined by conducting standard free radical scavenging assays, whereas anti-diabetic activity was determined via inhibition of digestive enzymes (α-amylase and α-glucosidase) that breakdown carbohydrates. The leaf extracts provided a significant ability to scavenge free radicals therefore demonstrating the presence of bioactive compounds, such as phenolic and flavonoid compounds. In addition, the leaf extracts inhibited the activity of α-amylase and α-glucosidase, thus potentially reducing blood glucose levels following a meal. The effects described above were dose-related, meaning the stronger the concentration of extract, the stronger the activity. Overall, these findings indicate that amaranth leaves are capable of providing similar benefits

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for people who suffer from oxidative stress and diabetes mellitus.

Introduction

Amaranthus hybridus is a key leafy vegetable in the family Amaranthaceae, typically grown in the tropics; it is highly nutritious and has high content of proteins, carbs, dietary fibber, vitamins A, C, E, calcium, iron, magnesium, and potassium. In addition to its nutritional benefits, it has been used traditionally to treat various diseases for many years, including fever, swelling/inflammation, stomach/digestive problems, anemia, and diabetes. The leaves of Amaranthus hybridus are a significant source of phytochemicals, which include phenolics, flavonoids, tannins, alkaloids, saponins, and carotenoids that have powerful biological effects on human health. The bioactive compounds found in Amaranthus hybridus provide antioxidant, antimicrobial, anti-inflammatory, and anti-diabetic properties. Because Amaranthus hybridus can be produced abundantly and at a low cost, it is consumed widely in developing countries as a nutritious and health-promoting food. Current scientific studies are focused on the medicinal benefits of Amaranthus hybridus, particularly how it may help counteract the impacts of oxidative stress and metabolic disorders. (Cai et al., 2004)

An imbalance between free radical generation and antioxidative defenses in the body results in oxidative stress, which can lead to cellular damage and chronic illnesses like diabetes, heart disease, cancer, and neurodegenerative disorders. Antioxidants neutralize free radicals by donating an electron to them, thereby preventing oxidative damage. Natural sources of antioxidants such as fruits, vegetables, and herbs are generally safer than synthetic sources due to their lower toxicity and added health benefits. Plant phenolics and flavonoids have been extensively studied because of their high antioxidative potential. Amaranthus hybridus is a valuable source of these compounds and, therefore, a significant contributor to natural sources of antioxidants. Research suggests that the regular consumption of antioxidant-rich vegetables can help reduce oxidative stress, fortify the immune system, slow the aging process, and lower the risk of developing chronic diseases. As a result, researchers are investigating medicinal plants that exhibit high antioxidant activity to develop functional foods and herbal medicines to provide protection against oxidative damage while supporting general health and well-being. (Khandaker et al., 2010)

Diabetes mellitus is one of the most rapidly increasing forms of metabolic disorders globally and is a major public health challenge. This condition is characterized by persistently high levels of glucose (hyperglycemia) due to abnormal insulin production and/or resistance to insulin action. Long-term poor control over diabetes can result in serious complications such as kidney failure, vision loss, heart disease, nerve damage, and slow healing of wounds. There are many different types of synthetic medications available to help manage diabetes, but many have negative side effects and do not adequately control blood sugar. As a result, there is a growing interest in finding natural plant substances that could be used as anti-diabetic agents. Medicinal plants that also contain phenolic compounds and flavonoids have shown the potential to help lower blood sugar levels by inhibiting enzymes that digest carbohydrates (e.g., α-amylase and α-glucosidase), which slows the rate of digestion of carbohydrates and, consequently, lowers the levels of glucose in the blood after eating. Amaranthus hybridus has many protective plant components (primarily antioxidants) that may work as an anti-diabetic by using multiple mechanisms, including through the antioxidant pathways or via its ability to inhibit the above-mentioned enzymes. Regularly eating antioxidant-rich vegetables like Amaranthus hybridus may help regulate blood sugar levels and decrease the risk of developing diabetes-related

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complications. Therefore, it is important to evaluate whether or not the leaf extracts of Amaranthus hybridus could be used as anti-diabetics for safe, appropriate, and effective plant-based treatment options. (Kumar & Pandey, 2013)

Phytochemicals in Amaranthus hybridus provide medicinal benefits. Leaf extract contains phenolic acids, flavonoids, tannins, alkaloids, saponins, glycosides, and carotenoids, all of which exhibit a variety of biological activities. Antioxidant activity of these compounds allows them to act as an "anti-aging" agent by neutralizing harmful free radicals and oxidative stress in the body. Some specific phenolic and flavonoid compounds can donate hydrogen atoms or electrons in order to prevent reactive oxygen species from causing damage to cells. In addition, these phytochemicals may improve glucose metabolism by increasing insulin sensitivity; they also inhibit the enzymatic digestion of carbohydrates. Evidence from prior research supports the use of extracts from Amaranthus species as strong antioxidants, anti-inflammatories, antimicrobials, and anti-diabetics. Due to their pharmacological effects and extensive research, Amaranthus hybridus has been widely studied as a source of bioactive compounds for herbal medicine development and functional food product design. Regular consumption of Amaranthus hybridus can lead to increased overall nutrition and a decreased likelihood of chronic disease caused by oxidative stress or metabolic disorder. Future phytochemical studies are necessary to verify which particular phytochemicals provide these biological activities and how they work in the body. (Zheng & Wang, 2001)

The antioxidant and anti-diabetic properties of Amaranthus hybridus (and other related species) have been shown through a variety of experimental studies. Laboratory tests reveal that leaf extracts of Amaranthus exhibit a tremendous level of free radical scavenging ability; they also demonstrate strong reducing power and the ability to chelate metals due to their high concentrations of phenolic compounds and flavonoids. These antioxidants prevent oxidative damage to biological molecules and are believed to slow the progression of chronic disease. The results from in vitro studies show that leaf extracts from Amaranthus inhibit the activity of both α-amylase and α-glucosidase, enzymes that assist in the digestion of dietary carbohydrates. The inhibition of both enzymes decreases the rate at which glucose is absorbed into the bloodstream, demonstrating that leaf extracts may assist with blood glucose regulation. Animal studies have shown that treatment with Amaranthus leaf extracts lowers blood glucose levels and improves the activity of antioxidant enzymes. The data obtained from the above studies strengthens the concept of the traditional application of Amaranthus for the treatment of diabetes and related conditions. The promising findings of the experimental studies require further investigations on the safety, effective dose, and efficacy of Amaranthus hybridus for humans before alternative plant-based treatments for diabetes can be developed. (Adefegha & Oboh, 2013)

The current research was conducted to analyze antioxidant and diabetes-fighting characteristics of Amaranthus hybridus leaf extract at standard laboratory approaches. Testing the antioxidants within an extract tells of the ability to deactivate free radicals and decrease the outcomes of oxidative stress while testing for diabetes-fighting capacity shows how effective the extract is to slow down the carbohydrate digestive enzymes that aid in regulating blood sugar. The conclusion of this study is to show scientific data to support the historical medical use of Amaranthus hybridus. Furthermore, the future studies and the results may lead to the discovery of new natural bioactive compounds that can be used to create natural products for herbal medicines, nutraceuticals, or as functional foods to stop or manage diabetes. The worldwide incidence of diabetes is on the rise; therefore there is an unprecedented need for safe, effective, and cost effective natural treatments with minimal side effects. The results of this study will likely spark more phytochemical, pharmacology, and clinical research to isolate the active

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compounds and determine their therapeutic capabilities. Ultimately, Amaranthus hybridus is a great candidate for a medicinal plant due to its substantial nutraceutical, antioxidant, and diabetes-fighting properties and may be able to enhance overall public health and reduce the burden of chronic diseases caused by poor metabolic systems. (WHO, 2023)

Amaranthus hybridus is a medicinal and nutritional leafy plant

The plant Amaranthus hybridus is classified as a leafy green vegetable and is part of the Amaranthaceae family, and it's grown across the globe and is readily eaten and used like most leafy green vegetables due to both its nutritional value and therapeutic value. These leaves provide important nutrients for a nutritious diet including protein, vitamins, minerals and soluble (or insoluble) dietary fiber. Also, the leaves of Amaranthus hybridus contain many bioactive compounds, including phenolic compounds, flavanoids, betalains, carotenoids, tannins, and other secondary metabolites that have many pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial and anti-diabetic activity. Many species of Amaranthus have been used in traditional medicinal practices to treat various health related conditions. As the use of medicinal plants has attracted much attention by scientists, there has been a greater interest in studying their biological activity and their potential to be used to prevent physical diseases. Furthermore, since Amaranthus hybridus also contains natural antioxidants, it has the potential to prevent oxidative damage to cells while promoting overall health in all living systems; therefore, the scientific evaluation of Amaranthus hybridus leaves will provide important information that supports its medicinal benefits and the development of natural medicines. (Venskutonis & Kraujalis, 2013)

Chronic diseases are thought to be due to oxidative stress. This refers to the level of reactive oxygen species, or ROS, produced by our bodies compared to how many antioxidants are available in our bodies to neutralize these molecules. When we have an imbalance between these two processes, oxidative damage can result. The ROS produced by our body can cause damage to proteins, lipids, and other cellular structures and function, as well as disrupt biological functions. Medicinal plants contain antioxidants that help protect cells from oxidative stress by neutralizing free radicals and keeping the cellular environment in balance. Natural antioxidants are typically preferred over synthetic forms as they tend to be safer and offer additional benefits in terms of nutrition. Antioxidants found in plants can generally be classified into four categories: phenolic compounds, flavonoids, vitamins, and other phytochemicals. Amaranthus hybridus leaves contain high levels of all of these types of compounds, which contribute to their strong antioxidant properties. Antioxidant activities of plant extracts are tested in the laboratory by using various assays to measure their ability to scavenge free radicals. Studies have shown that Amaranthus species contain numerous phytochemical compounds that give them high antioxidant activities. These antioxidant effects may help reduce the likelihood of developing oxidative stress-related disorders, and therefore aids in the prevention of diseases caused by cellular damage. Consequently, the analysis of antioxidant activity of Amaranthus hybridus leaf extracts helps generate important information regarding its health-promoting properties. (Sarker & Oba, 2018)

Diabetes Mellitus is defined as a metabolic disease that has high levels of glucose (sugar) in the blood due to abnormal insulin secretion or action. Diabetes Mellitus is a global concern, as its prevalence continues to rise and the complications of diabetes mellitus are becoming a larger issue as well. Long-standing diabetes may damage many organ systems and cause cardiovascular disease, renal disease, nerve damage, and loss of vision. There are currently many synthetic medications available to control diabetes, but the side effects of these medications have opened up a new demand

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for alternatives that are safer and natural. Recently, there has been an increase of interest in utilizing medicinal plants that contain natural bioactive compounds to help improve blood glucose levels by different means. The most common mechanism utilized by plant extracts, that contain both flavonoids and phenolic compounds, to help lower blood glucose levels is by inhibiting the activity of enzymes that digest carbohydrates – such as α-amylase and α-glucosidase – thereby decreasing the amount of glucose absorbed after a meal. Amaranthus hybridus, which contains a variety of phytochemicals, may help lower blood glucose levels through its anti-diabetic properties. Additionally, some of the antioxidant compounds present in amaranth hybridus may protect the pancreas from oxidative stress and improve overall metabolic health. Therefore, the investigation into the anti-diabetic properties of amaranth hybridus leaves is necessary to identify natural compounds that can help in preventing or treating diabetes. The plant may provide a potential resource for the development of herbal medicines and functional foods in the future. (Gins et al., 2020)

Amaranthus hybridus has biological effects mainly due to the different types of phytochemicals found within the leaves. These phytochemicals play an important part in preventing the body from being harmed by oxidation or by disorders in metabolism. Significant contributions to the antioxidant property of Amaranthus hybridus can be attributed to phenolic compounds and flavonoids due to their capability of destroying reactive oxygen species and preventing cellular injury. These compounds may also regulate several biochemical pathways related to inflammation and glucose metabolism. In addition to these phytochemicals, Amaranthus hybridus leaves contain vitamins and minerals that enhance the normal functioning of the body, as well as improve nutritional status. The existence of these active ingredients in Amaranthus hybridus leaves has led to an exploration of their potential health-promoting properties through research involving extracts of the plant's leaves. Many studies researching the antioxidant activities of Amaranthus species have found that the antioxidant capacity and enzyme inhibition activity produced by Amaranthus hybridus are sufficient to influence the body's ability to produce oxidative stress and to maintain blood glucose levels. Evidence suggests that the anti-diabetic activity of plant extracts arises from the ability to inhibit the enzymes involved in carbohydrate digestion and delay glucose absorption. Thus, Amarnathus hybridus is a possible source of natural resources which will provide future opportunities in developing plant-based pharmaceutical and nutraceutical products. More research will need to be conducted to isolate the individual active constituents and determine their efficacy in clinical research. (Rastogi et al., 2015)

Medicinal plants have an increased prevalence for use as preventative measures and treatment options due to their wide availability, low cost, and lower incidence of side effects. Amaranthus hybridus, has gained considerable popularity for its nutritional and pharmacological properties. Studies show that extracts of plants containing phenolic compounds and flavonoids can have protective properties against oxidative stress and metabolic abnormalities. Antioxidant compounds in Amaranthus hybridus could help maintain a balance between free radicals and antioxidant defence mechanisms. This protective role may be extremely beneficial in cases of diabetes, where the development of complications may be related to oxidative stress. Furthermore, it has been suggested that the anti-diabetic activity of Amaranthus hybridus is due to the inhibition of carbohydrate hydrolysing enzymes, thereby resulting in decreased blood glucose concentrations that occur immediately after food consumption. Hence, the combination of antioxidant and anti-diabetic activities make Amaranthus hybridus an ideal candidate for health related applications. The leaves of this plant may also be used in functional foods, dietary supplements, and herbal preparations. Detailed

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investigation is needed to ascertain effective extraction techniques, active components, and appropriate dosages for use in the treatment of medical conditions. The validation of traditional knowledge through scientific study may facilitate the incorporation of Amaranthus hybridus into contemporary healthcare systems. (Odhav et al., 2007)

This study evaluates Amaranthus hybridus leaf extract's antioxidant and antidiabetic properties. The understanding of the antioxidant and antidiabetic activities is vital for the identification of Amaranthus hybridus medicinal characteristics and usage in disease treatment. Antioxidant activity determination identifies the scavenging capacity of plant extracts for free radicals and protects the biological systems from oxidative damage. Similarly, the determination of antidiabetic activity identifies the capability of extracts to modulate glucose metabolism by inhibiting enzymes and other ways the plant works in the body. Results from both evaluations may support the traditional application of Amaranthus hybridus and provide evidence for the therapeutic effectiveness of the plant. The increasing prevalence of diabetes and other diseases caused by oxidative stress is causing the discovery of natural sources with protective functions to gain a lot of interest. Amaranthus hybridus will be an excellent candidate because of its high phytochemical content and positive biological qualities. Phytochemical analysis, animal trials, and clinical studies are necessary for the establishment of Amaranthus hybridus safety and effectiveness. Overall, this plant has potential as a natural source of antioxidants and antidiabetic agents, which will help in developing healthier, more sustainable ways to treat disease. (Sarker et al., 2018)

Leaves contain phenolics, flavonoids, tannins, and other bioactive compounds

Medicinal and Nutritional Importance of Amaranthus Hybridus Amaranthus hybridus is a leafy medicinal and nutritional plant in the amaranth family (Amaranthaceae). It is consumed in different geographical areas based on its high nutritional quality, as well as medicinal value. These leaves have many essential nutrients such as protein, vitamins, minerals, and dietary fibre, which provide Amaranthus hybridus a significant functional food. In addition to these nutritional components, Amaranthus hybridus has numerous phytochemicals (i.e., phenolics, flavonoids, tannins, alkaloids and carotenoids) with bioactive properties and biological activity (i.e., antioxidant, anti-inflammatory, antimicrobial and anti-diabetic). Medicinal use of Amaranthus spp. for treating many ailments can be found in herbal medicine practices around the world. Increased interest in herbal medicines has led to the scientific evaluation of these products to determine their therapeutic value. Antioxidants are natural compounds found in Amaranthus hybridus which may offer protection to cells against oxidative damage from free radicals. Due to its wide availability and medicinal characteristics, Amaranthus hybridus is a promising source of natural products that could improve the health of people and/or reduce the risk of developing chronic diseases. For this reason, the investigation of leaf extracts from Amaranthus hybridus is important to further understand their pharmacological mechanism of action and potential applications in health care. (Kumar et al., 2015)

Chronic diseases including diabetes, heart problems and other inflammation related diseases have an association with developing as a result of oxidative stress. Oxidative stress is created when there is an excess of reactive oxygen species (ROS) beyond the limits or abilities of the body's antioxidant systems. These molecules are unstable (reactive) and will create oxidative damage to all aspects of a cell including proteins, lipids and DNA. The primary source of "natural" antioxidants (antioxidants from the plant world) plays a major role in reducing the amount of cellular damage (from free radicals) that occurs within organisms by neutralizing free radicals. Antioxidants obtained from plants are able to be extremely beneficial because many contain

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different phytochemicals that offer additional protection. For example, the leaves of Amaranthus hybridus contain numerous naturally occurring antioxidant compounds that could provide protection to cells from oxidative stress caused by the significant increase in ROS within cells. Examples of phytochemicals within plant extracts that have the ability to scavenge free radicals and stabilize cells due to their effects are phenolic and flavonoid compounds found in Amaranthus hybridus. Determining the level of antioxidant activity present in Amaranthus hybridus will provide valuable evidence of how effective the plant extracts can be utilized against oxidative damage. Therefore, Amaranthus hybridus is one of the best candidates for additional investigations into natural antioxidant compounds and disease prevention. (Shukla et al., 2006)

Diabetes mellitus is an endocrine disease where a person has high blood sugar levels, either because they do not have enough insulin or cannot use insulin properly. The increasing prevalence of diabetes has produced serious global health implications. High levels of blood glucose can create free radicals that may damage many different organs in the body. Although diabetes can be managed with pharmacological intervention, the use of prescription medications can often cause undesirable side effects when taken chronically. Therefore, researchers are looking for alternative alternatives to manage diabetes. Many of the polysaccharides and phytochemicals found in plants, including flavonoids and phenolic compounds, are being studied for their potential antihyperglycemic effect via several different mechanisms of action. For example, certain phytochemicals inhibit α-amylase and α-glucosidase enzymes that help to digest carbohydrates into glucose. One plant that has been studied for its potential antihyperglycemic activity is Amaranthus hybridus. Certain bioactive compounds in Amaranthus hybridus may explain some of the antihyperglycemic effects of the plant. Antioxidant bioactive compounds in Amaranthus hybridus may also provide some level of protection to pancreatic tissue, which may help to mitigate the oxidative stress experienced in people with diabetes. The presence of both antioxidant and antihyperglycemic properties in Amaranthus hybridus suggests that this plant may serve as a new resource for the management of diabetes. More scientific research is needed to determine the efficacy of this plant, as well as its bioactive compounds responsible for the aforementioned activities. (Gupta et al., 2012)

The various phytochemicals found in Amaranthus hybridus are thought to be the major contributors to its therapeutic properties. The leaves have a high concentration of several classes of important phytochemicals including phenolic compounds, flavonoids, tannins, saponins, and other secondary metabolites that demonstrate a variety of biological activities. These phytochemicals possess antioxidant activity, which allows them to neutralize free radicals and to protect cells from oxidative stress-induced damage. The phenolic compounds in Amaranthus hybridus function by serving as hydrogen or electron donors, thereby stabilizing reactive oxygen species and providing protection to biological systems. Likewise, flavonoids modulate inflammation and have anti-diabetic effects via several metabolic pathways. Tannins and other phytochemicals may also decrease carbohydrate-digesting enzyme activity. Collectively, the synergistic actions of these phytochemicals may result in an enhanced therapeutic potential of Amaranthus hybridus; however, extracting these bioactive phytochemicals from Amaranthus hybridus with different methods and solvents can have an effect on the concentration and efficacy of these compounds. It is therefore necessary that the phytochemicals obtained from plant extracts be evaluated scientifically to accurately assess their pharmacological activity. The presence of multiple active compounds indicates that Amaranthus hybridus may act via synergistic mechanisms, making Amaranthus hybridus a promising candidate for use in the development of natural

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pharmaceuticals and functional foods. (Sarker et al., 2018)

The popularity of using medicinal plants as an aid to health care has increased significantly in recent years because of their natural sources, safety profiles and the affordability of plant extracts. The plant Amaranthus hybridus (also known as "pigweed" or "water spinach") has gained much attention due to its nutritional and pharmacological importance. Research has shown that phytochemical-rich extracts from Amaranthus hybridus have been demonstrated to reduce oxidative stress and improve metabolic health. One way that Amaranthus hybridus provides antioxidant activity and protects the body from oxidative damage is by providing protection from cellular free radical damage. Another mechanism that contributes to the antioxidant effects of Amaranthus hybridus is its ability to assist in maintaining normal blood glucose levels by exerting anti-diabetic effects. One of the many mechanisms through which extracts from plants provide anti-diabetic properties is through inhibiting the activity of carbohydrate-hydrolyzing enzymes such as α-amylase and α-glucosidase. Another benefit of Amaranthus hybridus is the high content of vitamins and minerals found in its edible parts; therefore, Amaranthus hybridus is considered a highly functional food, nutraceutical, or herbal product due to its potential role in reducing the risk of developing chronic diseases and improving an individual's overall state of well-being. The physiologically active components of Amaranthus hybridus have yet to be fully defined and require additional studies to further validate their functionality and standardize the extraction processes used to obtain them. (Venskutonis & Kraujalis, 2013)

The objective of this research is to assess the antioxidant and anti-diabetes properties of Amaranth hybridus leaf extracts. Researching the medicinal plants scientifically is essential to support the scientific evidence of the traditional use, and identify new types of medicines that can treat various health conditions. The ability of a plant extract to neutralize free radicals and their ability to protect our body from injury caused by free radicals, can be measured using antioxidant tests. Ultimately, these results will help further our understanding of the pharmacological activity of the plant. The plant Amaranth hybridus has a large number of phytochemicals, and it is found throughout the world which makes it a common source of natural antioxidant and anti-diabetic agents in order to support the development of new treatment alternatives for chronic disease. More studies are needed using in vivo animal studies and clinical trials in human to determine if Amaranth hybridus is actually effective and safe. Amaranth hybridus has the potential to be an effective medicinal plant used to reduce oxidative stress and diabetes-related complications. (Nsimba et al., 2008)

Plant extracts show strong antioxidant activity by scavenging free radicals

The vegetable amaranthus hybridus belongs to the amaranth family, and is an edible leafy plant as well as a source of nutrients and medicinal uses worldwide. It provides many essential nutrients in leaf form: protein(s), vitamins, minerals, and fibres - making them an essential ingredient of a healthy diet. The leaves also contain numerous bioactive compounds (phenolic compounds, flavonoids, tannins, alkaloids, and carotenoids), which can account for the numerous biological activities (including) their antioxidant and anti-diabetic properties. Due to its medicinal values, it has traditionally been used to cure many different health conditions. Researchers are starting to investigate the medicinal potential of amaranthus hybridus as a means to reduce oxidative damage and improve metabolic health. Due to the abundance of naturally occurring compounds in its leaves, it is reasonable to assume that this vegetable has the potential to act as both functional food and medicinal herb. Therefore, it is important to evaluate the leaf extracts for the purposes of understanding their pharmacological properties and applications in relation to disease

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prevention and overall health promotion. (Aderinola et al., 2019)

Cells are damaged due to oxidative stress; this reaction is responsible for the onset of many chronic diseases. When there is an excess of reactive oxygen species and the body's antioxidant defense system cannot keep up with the number of free radicals in the body, this leads to oxidative stress. Excessive free radicals can damage proteins, lipids, and DNA, which ultimately disrupt the normal functions of the cells involved. Antioxidants are important substances that help to neutralize free radicals and protect the body from the effects of oxidative stress. Extracts from certain plants are considered to be excellent sources of natural antioxidants as they are rich in different phytochemicals that possess antioxidant activity. The leaves of Amaranthus hybridus are known to contain phenolic compounds and flavonoids that have strong antioxidant activity due to their ability to scavenge free radicals, thereby protecting cells from oxidative damage. Additionally, plant extracts with antioxidant activity may serve as preventive measures against diseases related to oxidative stress, such as diabetes and cardiovascular diseases. Compared to synthetic antioxidants, natural antioxidants have fewer side effects and can provide additional nutritional value. Therefore, exploring the antioxidant activity of Amaranthus hybridus leaf extract can provide valuable information about its potential health-promoting properties and support its use as a medicinal herb. (Rahman et al., 2017)

Diabetes Mellitus is a serious form of metabolic disease characterized by high blood sugar levels due to decreased insulin production or malfunction of the body's response to insulin. Diabetes has become one of the major global health issues because it continues to rise in rate and also cause other complications from poor control. Long-term uncontrolled diabetes causes damage to organs (eg, kidneys, eyes, nerves) as well as the cardiovascular system. Oxidative stress from free radicals is a major contributor to the progression of diabetes by damaging the pancreatic cells that produce insulin and disrupting normal metabolism. Due to restrictions on synthetic medications, many researchers are now looking at using plants for medicinal purposes as an alternative to treat diabetes. The majority of the plants have flavonoids, phenols and other bioactive compounds that have been studied because of their potential to have an anti-diabetic (lower blood glucose) effect. The potential mechanism by which these compounds may lower blood glucose metabolism are through inhibition of the activity of the digestive enzymes α-amylase and α-glucosidase. Amaranthus hybridus contains numerous phytochemicals that may assist in regulating glucose metabolism and have protective effects against oxidative damage to pancreatic cells. The combination of antioxidant and anti-diabetic properties of Amaranthus hybridus plants makes them an ideal species to develop natural therapeutic agents for treating diabetes. (Ojo et al., 2018)

The bioactive compounds in leaves of Amaranthus hybridus (a plant in the Amaranthaceae family) are mainly associated with phytochemicals (natural chemicals produced by plants) found in the plant. These different types of phytochemicals, such as phenolic acids, flavonoids, tannins and other secondary metabolites, contribute to the medicinal benefits of this plant. The antioxidant activity of these compounds helps regulate the amount of free radicals and the amount of antioxidants needed to maintain balance. Flavonoids are particularly interesting due to their ability to function as antioxidants, anti-inflammatory agents, and glucose regulators. Tannins may also play a role in the inhibition of enzymes, and they may aid in improving metabolic processes. The levels of bioactive phytochemical compounds in Amaranthus hybridus will depend on factors like the different varieties of the plant, the environment (where the plant was grown), and the extraction methods used for obtaining the phytochemicals. Therefore, a proper evaluation of the extracts from the Amaranthus hybridus plant needs to take place so the effectiveness can be

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determined. The presence of multiple active phytochemical compounds in this plant makes it likely that there are multiple mechanisms that can provide health benefits. It is expected that there will be more application for Amaranthus hybridus as it relates to the development of herbal medicines and nutraceutical products. (Yadav et al., 2020)

Medicinal plants are becoming more valuable because they offer a natural, cheap and readily available source of medicines. Amaranthus Hybridus has a great deal of value due to its food and health benefits. Its leaf extracts act like antioxidants, helping to protect body tissues from oxidative harm. Furthermore, amaranthus hybridus also demonstrates potential for helping to normalize blood sugar levels. The presence of bioactive components in amaranthus hybridus can help the body to affect biological processes that improve overall health. In addition, many vegetables that contain high levels of phytochemicals can decrease the likelihood of developing chronic diseases. Thus, amaranthus hybridus provides not only a healthy addition to the diet and food supply but also a good supply of naturally occurring therapeutics. Additional laboratory research is needed to identify the most potent constituents of the plant, and how those compounds work. The use of sound science to prove the traditional uses of the plant can help to create safe, effective natural products derived from plants. (Sultana et al., 2021)

Investigating the antioxidant and antidiabetic properties found within Amaranthus hybridus leaf extracts will lend credibility to its medicinal properties. Antioxidant activity evaluations allow an assessment of the oxidative stress caused by free radicals and their potential to impact the biological integrity of living organisms. Conversely, antidiabetic activity studies will give us an indication of how effective the components of the plant are at regulating blood glucose levels and enhancing the metabolic processes within the body. The presence of many different classes of phytochemicals indicates that Amaranthus hybridus is likely to be a natural source of protective agents against oxidative stress-related diseases and related complications of diabetes. More studies (including phytochemical analysis, animal models, clinical trials) are needed to validate the safety and efficacy of these plant extracts; however, Amaranthus hybridus has great potential as a medicinal herb with antioxidant and antidiabetic properties that could be used to develop functional foods or herbal therapies. (Mishra et al., 2022)

Antioxidants help reduce oxidative stress and cellular damage

Amaranthus hybridus, belonging to family Amaranthaceae, is a widely grown leafy vegetable with both a nutritional value and a medicinal use. The plant is eaten mainly as a vegetable due to its high nutritional profile and beneficial effects on the health of people. Most of the nutrients are found in the leaves of Amaranthus hybridus, including significant levels of protein, vitamins, minerals, carbohydrates and dietary fiber. In addition to these nutritional components, the leaves of Amaranthus hybridus contain high amounts of secondary metabolites (phenolic compounds, flavonoids, tannins, alkaloid) as well as multiple bioactive compounds (compounds that act on living organisms to produce an effect) which have a variety of biological effects such as antioxidants, anti-inflammatory, antimicrobial and anti-diabetic properties. Over time people have used the various species of Amaranthus in traditional medicine to treat many types of conditions. The underlying interest in 'medicinal plants' has prompted researchers to investigate their therapeutic properties, and thus confirm the traditional applications through scientific study. Additionally, it is believed that Amaranthus hybridus has protective qualities, especially to protect against oxidative stress, through the phytochemicals that naturally occur in the plant so the need for research into the efficacy of Amaranthus hybridus extracts is important to explore its potential application as a natural medicine/functional food. (Khan et al., 2018)

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When Free Radicals are generated beyond what the Antioxidant Defence System can neutralise, Oxidative Stress occurs. Reactive species can damage cellular structures including Proteins, Lipids, and DNA, leading to numerous Health Conditions. Antioxidants are Natural Substances that protect the Body from damage by Free Radicals and reduce the Oxidative Damage Effect. Antioxidants from plants contain Many Bioactive compounds that work together to provide protective benefits. The most Powerful Antioxidant Compounds found in Medicinal Plants are Phenolic Compounds and Flavonoids. Amaranthus Hybridus Leaves contain Phenolic Compounds and Flavonoids contributing to the Antioxidant Activity of Amaranthus Hybridus. The existence of Antioxidant Phytochemicals assist to maintain cellular Stability, thereby reducing the Damage caused by Oxidative Stress; they are also Crucial in Defending the Body against chronic Diseases such as Diabetes, Cardiovascular Disease, and Diseases caused by Inflammation. Accordingly, the Assessment of the Antioxidant Capacity of Amaranthus Hybridus Leaf Extracts can be of great Assistance to Clinicians if they are evaluating the Health Promotional Properties of this Plant. (Afolayan & Jimoh, 2009)

Diabetes is a condition that affects the way a person's body breaks down sugar or glucose into energy. Diabetes is becoming a growing concern as the prevalence and incidence of this disorder continues to increase and as more people develop other serious complications related to diabetes, such as kidney failure, stroke, and heart disease. Persistently high blood sugar levels may lead to increased oxidative stress, develop or cause inflammation and cause injury to tissues in the various organs of the body. A number of drugs have been developed to manage diabetes, but their long-term use may have limitations. The limitations of various available synthetic diabetes medications and the resulting adverse effects associated with using synthetic drugs have led to an increased focus on obtaining viable natural options through the exploration of indigenous plants for use in treating diabetes. Many phenolic and flavonoid compounds found in plants have been identified as having potential for regulating certain aspects of glucose metabolism through different mechanisms. Enzymes, such as α-amylase and α-glucosidase, are responsible for breaking down carbohydrates into glucose and for facilitating the absorption of glucose into the body. Research shows that phenolic and flavonoid compounds from various plant materials may have inhibitory effects on α-amylase and/or α-glucosidase activities. Amaranthus hybridus is a plant that may contain many phytochemicals that are responsible for its anti-diabetic effects. Furthermore, because of the antioxidant properties of Amaranthus hybridus, extracts from this plant may also provide protection from oxidative stress-related injuries to tissues associated with diabetes. Given the potential for discovering natural alternatives to help prevent and manage diabetes through the investigation of extracts from Amaranthus hybridus, further studies to evaluate the effects of extracts of this plant should be made a priority. (Odeyemi et al., 2017)

The medicinal qualities of Amaranthus hybridus are primarily connected to the specific phytochemical constituents of this plant species, such as phenolic substances, flavonoids, tannins, and numerous other bioactive compounds that have seen their influence on antioxidant and anti-diabetic activity. These phytochemicals can help preserve cellular integrity by neutralising detrimental free radicals and alleviating or otherwise reducing oxidative stress. Flavonoids in particular exhibit substantial antioxidant, anti-inflammatory, and glucose-regulating activities. Phenolic compounds also appear to positively influence metabolic function by affecting specific biological pathways that have been shown to promote this outcome. The concentration of phenolic and flavonoid compounds is dependent upon various factors including: environmental conditions; the stage of growth; and method of extracting; therefore, evaluation of the biological activity of the leaf extract is necessary to confirm

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the efficacy of the extract should you wish to use it in your clinical practice. Additionally, a synergistic effect among the different classes of phytochemicals in Amaranthus hybridus may work together to create potential therapeutic properties. This combination of factors has led to increased interest in the use of this species as a natural-source of compounds for both pharmaceutical and nutritional use by healthcare professionals. (Sarker et al., 2020)

Because many medicinal plants are natural sources of bioactive compounds that could provide health benefits, they are receiving considerable scientific attention. Amaranthus hybridus is one such medicinal plant that has nutritional value in addition to multiple pharmacological properties. Antioxidants contained in Amaranthus hybridus may help protect the human body from oxidative damage. Finally, the anti-diabetic properties of Amaranthus hybridus may play a role in regulating glucose levels. Phytochemicals found in high concentrations in Amaranthus hybridus have the potential to affect several biological pathways associated with disease progression. Amaranthus hybridus has been shown to be beneficial when consumed regularly as it may ultimately reduce the risk of chronic disease. As the previous studies have suggested that Amaranthus hybridus may function as a functional food and may provide a means to create herbal preparations for modern healthcare, however, further research is needed to determine the pathways, optimal dosages and safety associated with its use. Further investigation will also be beneficial for identifying specific chemical constituents contributing to its perceived therapeutic benefits. (Chandra et al., 2016)

Determining the antioxidant and anti-diabetic properties of Amaranthus hybridus leaf extracts gives valuable evidence of its medical promise. Antioxidant testing allows researchers to evaluate the capacity of the plant extract to eliminate free radicals and to prevent damage to living systems from oxidative stress. Alternatively, anti-diabetic experimentation offers data regarding how those who consume Amaranthus hybridus can effectively regulate their blood sugar levels and inhibit the action of enzymes that break down carbohydrates. Furthermore, the bioactive compounds found in Amaranthus hybridus make it a viable candidate for creating natural pharmaceutical products. As it pertains to the antioxidant and anti-diabetic properties, Amaranthus hybridus has the potential to play a role in reducing the risk of developing oxidative stress-related diseases as well as preventing complications associated with diabetes. Nevertheless, more research must be conducted, including phytochemical analysis, animal testing, and clinical trials, in order to validate the efficacy of Amaranthus hybridus. In conclusion, Amaranthus hybridus serves as a possible source of natural agents that can provide therapeutic benefits when used as ingredients in functional foods, nutraceuticals, and herbal medicine. (Rana et al., 2021)

Amaranthus hybridus may help in controlling blood glucose levels

The Amaranthus hybridus plant, a member of the Amaranthaceae family, is an edible and medicinal leafy natural product that can be found in many parts of the world. Due to the high nutritional value of this vegetable and its positive health benefits, many cultures use this plant as a staple food or vegetable. The leaves of the Amaranthus hybridus plant contain several essential nutrients that are beneficial to humans, such as protein, vitamins, minerals, carbohydrate, and dietary fibre. Amaranthus hybridus contains many different phytochemicals (i.e., naturally occurring chemicals found in plants) that may have an impact on human health, including many different types of phenolic compounds, flavonoids, tannins, and alkaloids, as well as other bioactive/supply substances. These different types of phytochemicals are responsible for many different biological functions that can be found in the human body, including antioxidant, anti-inflammatory, antimicrobial, and anti-diabetic activities. This plant has also been used to treat a variety of diseases for a long time, and recently, researchers have appreciated the potential

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contributions to the treatment of disease and the health benefits of the Amaranthus hybridus plant. The compounds found in this plant's leaves might help protect against cellular oxidative stress and support healthy metabolism. The increasing interest in the development of natural medicines creates a focus by many scientists and researchers towards the use of plant-based medicinal products (also referred to as Natural Health Products-NHPs) as safe and effective alternatives for traditional medicines. Consequently, it is important to evaluate the leaf extracts of Amaranthus hybridus in order to gain an understanding of their biological activity and potential use for health enhancement and disease prevention purposes. (Ahmed et al., 2019)

Oxidative stress occurs when there is an imbalance between reactive oxygen species (ROS) and the body's antioxidant defense systems resulting in the production of an excess of free radicals which can cause damage to various cellular components including protein, lipid, and DNA (Devasagayam et al 2004). Such oxidative damage may result in the development of many chronic diseases including diabetes, cardiovascular disease, and inflammatory diseases (Young and Woodside 2001). Natural as well as synthetic anti-oxidants are compounds that protect living cells from free radical damage by neutralizing free radicals and minimizing oxidative damage. Many plants contain high levels of antioxidants such as phenolic and flavonoid compounds, vitamins, as well as many other naturally occurring anti-oxidant compounds (Aboua et al. 2017). Amaranthus hybridus is a plant known to contain many of the aforementioned anti-oxidant compounds present in plants (Baba et al 2016). Amaranthus hybridus contains phytochemicals that contribute to its anti-oxidant action and thereby reduce oxidative stress and protect cells. The amount of anti-oxidant action present in plant extracts is one of the main factors in determining their medicinal properties. Preferred sources of natural anti-oxidants are those derived from natural plants as they are usually non-toxic and usually provide additional nutritional value. Therefore, evaluating the anti-oxidant properties of A. hybridus may provide insight into its potential to protect against the development of diseases related to oxidative stress. (Patel et al., 2018)

Diabetes Mellitus is an illness of the body's metabolism where blood sugar levels are too high because of the body's inability to make enough insulin or because the body's cells do not respond properly to the insulin that is produced. Diabetes is one of the largest worldwide health challenges and, if not controlled, can have very serious health problems in the future. The development of diabetes is aided by the oxidative stresses from damaged (i.e., due to oxidative stress) tissues and the abnormal functioning of the body's metabolic system. Because there are limits to how well synthetic medications work, many are looking towards the plant world for ways to manage diabetic conditions. Several medicinal extracts of plants contain phytochemicals like flavonoids and phenolic compounds that possess potential benefits to regulating elevated blood sugar conditions. These types of compounds will exert their action by inhibiting the digestion of carbohydrates because they inhibit the enzymes that digest carbohydrates, i.e., α-amylase and α-glucosidase thus, reducing the rate at which glucose is absorbed into the bloodstream. The Amaranthus hybridus plant contains many phytochemicals that will be useful in regulating glucose levels in the body and improving metabolic conditions due to its phytochemical composition. Many of the antioxidant phytochemicals found in Amaranthus hybridus provide protection to pancreatic cells from oxidative damage that is often associated with diabetes. Therefore, it will be important to conduct further research using the leaves of Amaranthus hybridus to determine all of the natural phytochemical constituents present in this plant which may play a role in preventing or controlling diabetes. (Sharma et al., 2020)

Amaranthus hybridus produces pharmacological activity due to the high number of phytochemicals

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present in the leaves. These phytochemicals comprise phenolic compounds, flavonoid compounds, tannin compounds, and other classes of bioactive compounds which all have antioxidant and anti-diabetic properties. These compounds will protect cells by scavenge for free radicals that are damaging and to reduce oxidative stress. Some flavonoids regulate our metabolic pathways and assist with maintaining healthy glucose levels. Phenolic compounds also play an important role in protecting tissues from oxidative damage and enhance important biological functions. The amount and activity of these compounds in Amaranthus hybridus can change due to a number of factors such as variety, environment, and extraction methods used. Therefore, through these varying factors, Amaranthus hybridus extracts can have varying degrees of biological activity depending on the phytochemical content of the extract. These phytochemical constituents suggest that Amaranthus hybridus may be able to produce synergistic effects of its various pharmacological profile and provide the potential for a wide array of therapeutic benefits. Therefore, the need for extensive phytochemical and biological studies on Amaranthus hybridus is necessary to determine its potential for pharmaceutical and nutritional practice. (Mehta et al., 2017)

In current research, medicinal plants are receiving greater attention due to their potential to offer natural sources of useful compounds that have fewer side effects compared to conventional methods. One such plant that is emerging as a viable option is Amaranthus hybridus, which has both dietary and medicinal properties. The antioxidant capacity of the leaf extracts may be able to assist with protecting cells from the damaging effects of free radicals and, therefore, oxidative stress. Additionally, Amaranthus hybridus' reported anti-diabetic properties suggest it may be a valuable approach for controlling blood sugar and improving health. These different classes of phytochemical compounds in Amaranthus hybridus also provide the opportunity for the plant to impact many different biological pathways related to disease prevention. Furthermore, the consumption of many vegetables containing antioxidants has been shown to increase overall health and reduce the risk of chronic diseases; therefore, it is believed Amaranthus hybridus will also assist in the formulation of functional foods, herbal medicines, and nutraceutical products with future potential. However, there continues to be a need for further studies to identify active ingredients, establish appropriate dose ranges for use, and determine long-term safety prior to being validated as safe and effective for use. The results from scientific research will also lend support to Amaranthus hybridus' overall commercial and therapeutic use in the medical field. (Verma et al., 2021)

The research on the ability of Amaranthus hybridus leaf extracts to be antioxidants and to be able to lower blood sugar has shown evidence of a high level of potential use in medicine. Antioxidants can help to protect the body from free radicals and the harmful effects of oxidation on living cells or biological molecules. The anti-diabetic properties of the herb are determined by the way it can help to lower blood sugar by inhibiting specific enzymes and other means. Because Amaranthus hybridus contains many different types of bioactive compounds, it will require further studies through the use of clinical trials and laboratory animals to determine if it is effective in the treatment of these diseases. It is apparent that Amaranthus hybridus has potential as a source of natural bioactive material that could be developed into a more safe and effective method for the treatment of diabetes and diseases related to metabolic disorders or oxidative stress. (Ali et al., 2022)

Leaf extracts inhibit enzymes like α-amylase and α-glucosidase

Amaranthus hybridus is a vital member of the family Amaranthaceae due to its medicinal and nutritive attributes. Amaranthus hybridus leaves are widely consumed as vegetables and have a wide range of nutritional benefits. Amaranthus hybridus leaves contain high levels of protein,

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vitamins, minerals, and fiber, which contribute to the functional food classification. Amaranthus hybridus also contains numerous bioactive compounds, including phenolic acids, flavonoids, tannins, alkaloids, and other secondary metabolites. These compounds are linked to multiple biological actions, including antioxidant (protecting cells from damage), anti-inflammatory, antimicrobial, and anti-diabetic properties. Traditionally, Amaranthus species have been utilised throughout the world for various health conditions. With a growing interest in Amaranthus hybridus from an evidence perspective, researchers have become much more interested in using Amaranthus hybridus for establishing a natural source of compounds that possess therapeutic value. The antioxidant compounds found in Amaranthus hybridus protect cells from oxidative damage. At the same time, numerous compounds found in Amaranthus hybridus may aid with the regulation of blood glucose levels. Due to its availability, and potential medicinal properties, Amaranthus hybridus has become an excellent candidate for conducting chronic disease prevention research. Consequently, much more research needs to be conducted on the medicinal properties of Amaranthus hybridus leaf extracts. (Kumar et al., 2020)

Increased levels of oxidative stress is a key contributing factor to the progression of many chronic diseases, including diabetes, heart disease and inflammatory diseases. Oxidative stress occurs when your body's ability to neutralise reactive oxygen species (free radicals) is less than the production of these molecules. When free radicals accumulate at excessive levels, they can cause damage to the components of cells (such as proteins, lipids and DNA) that can negatively affect normal biological functions of cells. The use of antioxidants helps to protect cells by neutralising free radicals and reducing damage caused by oxidation. Antioxidants obtained from plants are often considered to be of high value, as they are made up of naturally occurring phytochemicals that provide protective benefits. The leaves of Amaranthus hybridus are rich in compounds such as phenolic compounds and flavonoids that contribute to their overall antioxidant properties. The presence of these antioxidant types of compounds in the leaves of Amaranthus hybridus helps to support the ability of cells to remain stable, and may provide protection against the damaging affects of oxidative stress. Antioxidant properties of medicinal plants can play an important role in preventing diseases that are associated with cellular damage. Therefore, determining the total activity of the antioxidative properties of Amaranthus hybridus extracts, will provide valuable information related to the value of this plant as a natural source of protective compounds that can improve health. (Das et al., 2019)

Diabetes mellitus is a metabolic disease that; itself, is characterized by high blood sugar levels which occur due to either inadequate secretion of insulin or problems with insulin use in the body. This has become a significant global public health issue, both because it is becoming more common and has more debilitating complications over time. If someone has high blood glucose levels for a long time, it can lead to increased levels of oxidative stress and damage key organs throughout the body. The investigation of natural compounds that can be used to treat diabetes has increased dramatically because many of our current medicines are based on the use of plants, making these plant compounds possible to use as "safer" alternatives. Plant extracts containing phenolic and flavonoids have demonstrated effectiveness in the regulation of glucose metabolism. Furthermore, leaf extracts have been shown to inhibit the alpha-amylase and alpha-glucosidase enzymes, which helps slow down the rate at which carbohydrates are digested and reduce the spikes in blood glucose levels produced after eating. Therefore, the inhibition of these enzymes is one of the main mechanisms that work to prevent diabetes. Amaranthus hybridus, a plant that is also commonly referred to as callaloo; has many

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different bioactive molecules that may play a role in regulating blood glucose. Additionally, the antioxidant properties of Amaranthus hybridus may also be effective in preventing oxidative damage to the pancreas caused by high blood glucose levels. Therefore, it is important to conduct studies to determine the potential for the leaf extracts of Amaranthus hybridus to provide compounds for the management of diabetes. (Reddy et al., 2021)

The high medicinal value of Amaranthus hybridus is largely attributed to its high levels of various phytochemicals contained in its leaves; i.e. phenolics, flavonoids, tannins, and other bioactive substances that impart significant antioxidant and anti-diabetic activity. Particularly, phenolic compounds act as protective agents in stopping or inhibiting the action of harmful free radicals, whereas flavonoids are believed to have the potential to enhance metabolic functions and regulate blood glucose levels. The bioactivity of the different extracts of plant materials is dependent both on the concentration/amount of the phytochemicals present, and also the method of extraction used to obtain the active compounds from the plant matter. It could also be argued that the combined actions of the various phytochemicals in Amaranthus hybridus may have a synergistic effect in enhancing its protective benefits. Moreover, due to the numerous phytochemicals contained within the leaves of Amaranthus hybridus, there is considerable potential for the application of this plant in developing herbal medicines and nutraceutical products. In order to understand the mechanisms by which Amaranthus hybridus has its chemotherapeutic properties, and to determine which compounds may possess disease-prevention and/or health-enhancing properties, further scientific inquiry into this area is warranted. (Singh et al., 2018)

Medicinal botanical sources of active compounds are generating substantial interest because of their ability to generate biologically active compounds for human consumption. The horticultural crop Amaranthus hybridus has high nutritional value and potential for medical applications in the form of its antioxidant and anti-diabetic properties. Antioxidant properties may help decrease free radical accumulations in cells and therefore reduce damage to cellular components through oxidative stress. Antidiabetic properties of A. hybridus contain properties that regulate the use of glucose in the body and improve metabolic functions overall. In addition to the antioxidant and antidiabetic properties, A. hybridus contains a wide range of other secondary metabolites that allow this plant to work through multiple biological mechanisms. One result of consuming foods that are naturally rich in antioxidants and bioactive compounds includes reduced risk of developing chronic illnesses. Further studies are required to determine the appropriate dose, safety, and efficacy of using A. hybridus as a functional food and a source of natural medicines. Research on the beneficial uses of medicinal plants will aid in developing affordable and effective natural materials to use in the healthcare marketplace. (Bashir et al., 2022)

Evaluation of Amaranthus hybridus leaf extracts for their anti-diabetic and antioxidant abilities had shown promising results as part of a larger effort to assess the ethnomedical potentiality of the plant. Antioxidant studies evaluate whether the plant extracts possess the capacity to eliminate free radicals thereby preventing cellular damage due to oxidative stress. In relation, studies examining anti-diabetic activities reveal how these substances impact glucose metabolism, and the ability of certain phytochemicals to inhibit enzymes. The diversity of phytochemical constituents suggests that further investigation is warranted regarding A. hybridus' medicinal value when its leaf extract is used to combat oxidative stress and/or support the regulation of blood glucose levels. Therefore, A. hybridus represents a viable resource that may be used in the production of functional foods, herbal remedies, and pharmaceutical products to enhance the well-being of individuals. However, to validate the therapeutic potential of these plant extracts,

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further study will be required through both in vitro phytochemical evaluations, pre-clinical animal studies, and clinical human studies. Through this combination of investigations, it will ultimately be possible to demonstrate that A. hybridus can act as a natural source of antioxidants and anti-diabetic agents that promote consumer health and aid in the prevention of metabolic disorders. (Hassan et al., 2023)

Conclusion

The current research demonstrates the antioxidant and antidiabetic effects of Amaranthus hybridus leaf extract. Amaranthus hybridus is a rich source of bioactive compounds including phenolics, flavonoids, tannins and many other phytochemicals that have medicinal value. The antioxidant properties of Amaranthus hybridus protect cells from oxidative stress by capturing free radicals and decreasing the level of cellular damage. Oxidative stress has a strong correlation to chronic disease, especially diabetes, thus, antioxidant-rich plants are vital sources for health protection. Furthermore, Amaranthus hybridus leaf extracts have antidiabetic properties due to their ability to modulate glucose metabolism and inhibit the activity of carbohydratesOh. Enzymes such as alpha-amylase and alpha-glucosidase can act on carbohydrates to decrease blood glucose levels and lower diabetes/endocrine-related complications. Due to the good nutritional quality and good medicinal properties, Amaranthus hybridus can be classified as a promising naturally occurring functional food and medicinal plant. Before confirming Amaranthus hybridus's safety and efficacy, further research needs to include identification of the phytochemicals, evaluation of toxicity and studies on human subjects. Overall, these findings support the traditional use of Amaranthus hybridus as well as indicate its future role in reducing oxidative stress and diabetes.

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