CHAPTER 16

Insights into the Anti-Diabetic, Phytochemical, Antioxidant and Antimicrobial Potentials of Corn Silk

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SUMMARY

Corn silk is a thread-like structure found on the corn cob and is found to have nutritional and medicinal benefits. Historically, corn silk has been known for its diuretic, anti-inflammatory and antioxidant properties in native American, Chinese, Asian and European herbal medicine. Contemporary researchers have found its anti-glycemic, antihypertensive, anticancer, antihepatotoxic, nephroprotective, and antibacterial properties. Corn silk is also found to be nutritionally packed with proteins, carbohydrates, fiber, Vitamins and minerals such as Calcium, Magnesium, Sodium, Potassium, Zinc, Iron, Silicon and Phosphorus, etc. It is extensively used as an antioxidant in herbal teas, functional foods, and supplements because of its rich composition of phytochemicals, especially flavonoids. Corn silk has also been found to improve glycemic metabolism, prevent diabetic neuropathy, nephropathy, retinopathy, and improve kidney and liver function. Furthermore, it's found to be useful in treating common infections due to their antibacterial properties. Its effectiveness in controlling and preventing a range of chronic diseases is attributed to its bioactive constituents, which include polysaccharides, phenolic acids, and flavonoids. Hence, the potential of corn silk as a natural, affordable means of improving health and preventing disease is highlighted by its incorporation into modern dietary and therapeutic practices.

INTRODUCTION

Corn silk, (Maydis stigma), is a corn by-product. It has a yellow silky appearance and wraps the corn cob (Singh et al., 2023). Corn is Pakistan's third most common crop yearly (Pakistan Production, 2024). Corn silk is the byproduct of corn, so it is majorly used in the industry. It is used for conventional purposes such as manure, agricultural waste, and animal feed (Lee et al., 2017). Further, corn silk is used as a medicinal therapy, it is highly popular among Chinese people with multiple health benefits, such as treating rheumatoid patients, gout disease, and even cystitis. It is safe for humans to consume (Adetunji et al., 2022).

However, it is also a source of alkaloids, volatile oils, saponins, and other steroids such as stigma-sterol and sitosterol (Ho et al., 2017). Corn silk also contains resins, mucilage, flavonoids, and maizeric acid, which reflects its anti-diabetic, antibacterial, anti-oxidative, and anti-fatigue properties (Zhao et al., 2017). It is not only used for conventional purposes; it is also a therapeutic remedy for people in many other countries other than China, such as France, Turkey and the United States, corn silk tea is abundant there. This tea acts as a mild diuretic and is helpful for angina pectoris patients (Ab Razak et al., 2022). Due to its diuretic effect, it helps to mitigate conditions like hypertension, hyperlipidemia, and hypertension. Corn silk treats patients with oedema, cystitis, urinary tract infections, kidney stones and prostate disorders (Saad et al. 2021).

Industrially, corn silk production has helped business owners in many ways. Corn silk is processed and used in crackers, biscuits, breads, and even patties. Due to its bioactive role and nutritional composition, business owners have been using it to increase the nutrient value of the products. It adds value to nutraceutical food products. Therefore, it has been successful in the nutraceutical food industry globally (Kaur et al., 2023). The thread-like fiber known as corn silk is located at the top of corn cobs. Although it is not typically consumed, some people use it as an herbal medicine, antioxidant, and anti-inflammatory for various ailments (Hasanudin et al., 2012). Across many cultures, maize silk has long been used in traditional medicine, food, and nutrition. Its presumed nutritional value and health advantages have long been linked to its inclusion in food (Kaur et al., 2023).

TRADITIONAL USES IN FOOD

Native American Cuisine

Corn silk was used in the cooking of Native American cultures, who were among the first to cultivate and use it. Dried

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corn silk was frequently added to broths or used to make teas. People drank these teas because they believed they were good for their health, especially for heart problems, urinary tract problems, and malaria. Corn silk's mild, sweet flavor made it an excellent addition to a variety of herbal blends, which was thought to enhance the beverage's flavor and its medicinal qualities (Hasanudin et al., 2012).

Traditional Chinese Cuisine

Corn silk, also called "Yu Mi Xu," has been used for millennia as a nutritional supplement and therapeutic element in traditional Chinese medicine. It is frequently steeped into tea and drunk as a daily dietary supplement. Corn silk herbal tea is found to be a diuretic which is utilized to treat nephrolithiasis, edema and hypertension due to its diuretic properties. Hasanudin et al., (2012) have reported the addition of corn silk in Chinese soups to increase the nutritional and health benefits of the soups. Corn silk herbal tea is very famous among Chinese and Asian health enthusiasts. Corn silk has the potential to improve health as it has a great ability to control blood sugar levels and urinary health (Singh et al., 2023).

Practices in South America

Corn silk was domesticated in Mexico around 9000 years ago and it is widely drunk as a tea due to its mild and sweet flavor in traditional diets in South America especially Brazil and Mexico. Farsi et al., (2008) reported that corn silk tea has been traditionally consumed as a diuretic due to its detoxification properties and it also controls obesity and hypertension. In Mexico, corn silk infusions are also added with other herbs to make refreshing and healthy drinks. Hasanudin et al., (2012) has emphasized on the potentials of corn silk as a functional food and medicinal remedy due to its reported consumption in various ancient methods.

European Herbal Remedies

During the 19th century, the diuretic properties of corn silk made it a popular tea in Europe and widely taken as a medicinal cure to soothe urinary tract infections. It is widely consumed to treat prostatitis, bladder discomfort, and cystitis by the European herbalists. Other than its medicinal uses, corn silk tea is a famous herbal tea due to its mild and subtle flavor. It was occasionally powdered and dried to be added to food or supplements, which was standard then and represented a more significant trend of introducing herbal medicines into regular meals (Adetunji et al., 2022).

MODERN USES OF CORN SILK

Corn Silk Tea

Corn silk tea is employed as a medication in Traditional Chinese Medicine for the management of the conditions of the kidney and the bladder such as pain and burning during urination due to kidney stones and cystitis. Similarly, corn silk tea’s wide acceptance as a health-cipher liquid is evidenced by its prescription for treating disorders of the urinary system among the native American and South Americans. Corn silk contains other forms of bioactive substances such as the tannins, saponin and flavonoids that have been found to eradicate oxidative stress as well as, inflammation from the body hence making it to possess anti-inflammatory as well as antioxidant features (Adetunji et al., 2022). It also contains vitamin C and minerals such as potassium and magnesium which gave it the status of a diet supplement (Hasanudin et al., 2012).

Furthermore, corn silk is found to be consumed in weight loss journeys, however, reported to imbalance body electrolytes and lead to dehydration, if not used in moderation. It helps in flushing out the additional sodium and hence, decreases water retention in the body and makes it look slimmer, therefore, it is highly valued due to its purifying properties in various detox diets and cleansing regimens. A recent study has also shown its potential benefit to improve heart health and treat cardiovascular diseases because of its anticholesteremic and antihypertensive properties (Wahjuningsih, 2020).

Supplements and Food Products

The antioxidant properties of corn silk make it a suitable supplement to be consumed by health and diet conscious individuals and has made it a key ingredient in various food products and dietary supplements. It is commercially available in various supplemental forms such as tablets, liquid extracts and powders. Corn silk extracts are mostly utilized as tinctures which are consumed by adding in tea, water and/or other drinks. Those seeking out more potent effects tend to consume extracts that are concentrates of corn silk (Shalihah et al., 2020). Furthermore, corn silk powder is obtained by drying and grinding the silk fibers which is later used in soups, smoothies and drinks for its health benefits and as a dietary supplement in capsules (Wahjuningsih, 2020). Supplements of corn silk powder or extract helps in maintaining health at a low dosage.

NUTRITIONAL COMPOSITION AND BOTANICAL ASPECT

It is noteworthy that fresh corn silk is pale green. However, after some time, the silk turns reddish, yellow or light brown (Limmatvapirat et al., 2020). Corn germination in the developmental process starts with the formation of radicle and plumule which in turn forms roots and shoots. The growth stages of corn encompass two significant phases: Somatic (vegetative) phase vs. the generative phase (Mendoza-López et al., 2018). The growth of a corn plant can be divided into two main stages: The vegetative and the reproductive stages (Sun et al., 2018).

The vegetative stage consists of six phases: It has been applied in the monitoring of seedling emergence, specifically the first, second, and third leaf unfolding, last leaf unfolding and tasseling (Wang & Zhao, 2019). The reproductive stage includes the silking stage, blistering stage, milk stage, dough stage and dent stage and lasts up to physiological maturity. In the process, corn silk has significant functions owing to the trapping of pollen for pollination (Limmatvapirat et al., 2020). Every silk thread grows a grain with pollen (Wang & Zhao, 2019). Before the process of pollination, this silk is harvested from the corn when it is 30 cm in length; it can be used fresh or dried and therefore, is a very useful product (Mendoza-Lopez et al., 2018). The nutritional composition of corn silk is diverse. According to Nawaz et al. (2018), it has 9.65–10.4% moisture, 0.29–4.74% of fats, 7.34% of dietary fiber, 0.29–4.74% of lipids, 9.42–17.6% of protein, and 65.5–74.3% carbohydrates. It also has minerals such as magnesium, calcium, iron, zinc, potassium, sodium and copper.

Corn silk also contains many phytochemicals, which are non-nutritive plant compounds that are mostly distributed in fruits, vegetables, and medicinal plants. These are involved in numerous plant development processes and the color, scent, taste, and feel of plants. Antioxidants are known to help combat oxidation reactions and minimize the impact of ROS within humans and the food supply chain. For instance, in the food processing industry, nutritional antioxidants are used to preserve taste, appearance and texture of foods since they delay rancidity by interfering with lipid peroxidation. It thereby preserves the quality and longevity of food and pharmaceutical items, as well as protects the human body from the harm that free radicals and ROS can bring. Free radicals are formed internally by the natural metabolic processes, and externally by stress, solar radiation, smoke, fumes, pesticides, and chemicals (Lourenço et al., 2019). Oxidative stress takes place when the generation of ROS is greater than the capability to neutralize them, and ROS are believed to be involved in various ailments including diabetes, cancer, arthritis, and premature aging. Therefore, there is immense pressure on food producers to try out new novel, natural and safe ingredients, especially plant-derived antioxidants that are affordable, stable during processing, possess no undesirable attributes, easy to blend and soluble in the final product (Gutiérrez-del-Río et al., 2021). Knowledge of compositions of corn silk extracts is crucial in describing their activities which are largely attributed to their flavonoids content. Flavonoids are considered a class of plant phenylpropanoids which are spread throughout the plant kingdom; they have the ability to work as antioxidants (Pietta, 2000). In traditional Chinese medicine, bioactive and fibrous compounds (Table 1) in corn silk are believed to offer various health benefits and aid in the prevention of chronic diseases such as edema, cystitis, gout, rheumatism, and rheumatoid arthritis. Additionally, several in vivo and clinical studies have confirmed that corn silk is safe for human consumption. Due to these advantages, corn silk is being incorporated into the creation of value-added food products like beverages and patties. Moreover, research on 10 different corn silk genotypes has identified a significant number of bioactive components, including flavonoids and phenolics, as well as highlighted the antioxidant properties of corn silk polysaccharides (Singh et al., 2022).

HEALTH BENEFITS OF CORN SILK

CS was in the past considered as a waste material but increasing discoveries of its benefit to health are making it more popular. Investigations have been carried out on the use of corn silk extracts and their active phytochemicals for their anti-diabetic, anticancer, antihepatotoxic, nephrotoxic, and antibacterial potential. It also has proteins, carbohydrates, vitamins, minerals, fixed and volatile oils, phenolic compounds, all which are believed to be responsible for the health benefits of corn silk (Mada et al., 2020).

Anti-Diabetic Activity

It is important to note that this part of corn has been known to exhibit diuretic effects which could lead to health dangers when used alongside prescribed drugs such as anti-hypertensive or diabetic ones. A healthcare provider should always be consulted before starting any supplement regimen. Diabetes mellitus refers to a complex metabolic disease where the body fails to produce or use insulin properly, leading to raised blood sugar levels (Ibrahim et al., 2016). Conventional antidiabetic drugs may affect insulin release, glucose uptake by target tissues, and food intake (Ghada et al., 2014).

This way, CS can increase the levels of insulin secretion and, consequently, stabilize the β cells and improve the glycemic metabolism from the hyperglycemia perspective [Fig. 1 (Chen & Guo, 2018)]. Findings from prior studies using streptozotocin-induced diabetic rats showed that antidiabetic properties, characterized by a decrease in lipid profiles and blood glucose levels, corresponded to the daily injection of 100–500 mg/kg body weight maize silk polysaccharide. The Corn silk polysaccharides enhance glucose tolerance in diabetic rats through conducting an oral glucose tolerance test (OGTT) (Chen & Guo, 2018). Moreover, in type 2 diabetic rats, these polysaccharides have the potential to improve glucose tolerance, reduce the blood glucose concentration, increase blood insulin level, and reduce the rate of body weight loss. Another study revealed that administration of methanol and corn silk extract at the dosage of 250, 500, and 750 mg/kg reduced the raised blood sugar levels of the diabetes induced rats in a dose dependent manner with the two highest doses showing the best effect (Umar, 2016). Moreover, studies on glucose transport utilizing isolated rat hemi-diaphragms highlighted the fact that corn silk undoubtedly facilitates glucose uptake in peripheral tissues and may prove more potent than insulin (Chen et al., 2013).

According to Chen et al. (2013), CS inhibits the enzyme activity of α-amylase, postpones starch digestion, and stops blood glucose from rising after a meal. Additionally, it impacts the absorption of glucose, inhibits the activity of α-glucosidase, controls the metabolism of glucose, and enhances the effects of insulin (Chen & Guo, 2018). Consequently, CS has the potential to be a useful bioactive component in the management of diabetes (Vijitha & Saranya, 2017).

Zea mays produces corn silk, which has long been used as a diuretic in Chinese medicine. It is also well known for helping to treat chronic nephropathy and having antihyperglycemic properties. Suzuki et al. (2005) looked at the potential benefits of maize silk aqueous extract on diabetes

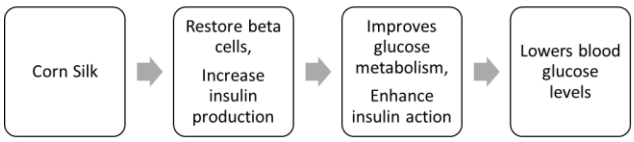

Fig 1. Effect of corn silk on diabetes mellitus patients

Table 1: Physiochemical Composition of Corn Silk

Class of phytochemicals	Component of phytochemicals	Amount present	References
Polyphenols	Saponins, tannins, steroids, alkaloids, resins, anthocyanins, hesperidin, cardiac glycosides and allantoins.	Total phenolic content 8101.6 ± 73.5 to 10,160.8 ± 250 mg CGAE per 100 g. Flavonoid content 5565 ± 40.9 and 6478.3 ± 409.9 mg CE per 100 g. Anthocyanin content 192.9 ± 0.3 mg CGE per 100 g. Proanthocyanidin levels 69.4 ± 6.6 mg per 100 g.	Câmara et al., 2020; Zilic et al., 2016
Phenolic acids	vanillic acid, p-coumaric acid, para-aminobenzoic acid (PABA), chlorogenic acid, protocatechuic acid, ferulic acid, caffeic acid, manic acid, 3-O-caffeoylquinic acid, and hydroxycinnamic acid ester	Phenolic content: 94.10 ± 0.26 mg GAE/g 3-O-caffeoylquinic acid: 22.6 ± 0.9 to 49.9 ± 1.4 mg per 100 g	Sing et al., 2022; Zilic et al., 2016
Flavonoids	Isoflavones, catechin, protocatechin, quercetin, rutin, flavone, 3-hydroxyflavone, 4-hydroxyflavone, 5-hydroxyflavone, 7-hydroxyflavone, C-3-deoxyglucosyl-3-methoxy luteolin, and 6,4-dihydroxy-3-methoxyflavone-7-O-glucoside.	Rutin: 0.1398 mg/L Quercetin: 0.11 mg/L Maysin derivatives: 1.1 ± 3.6 (593 m/z) Methozymaysin derivatives: 1.2 ± 0.1 to 4.9 ± 0.3 Flavonoid content: 163.93 ± 0.83 mg QE/100 g	Singh et al., 2022; Singh et al., 2023
Carotenoids	Zeaxanthin, beta-carotene	Total carotenoid content: 11.3 mg CGE per 100 g dry weight (ethanolic extract)	Moongngarm et al., 2020; Laeliocattleya et al., 2014
Sterols	Beta-sitosterol, phytosterol like stigmasterol	Stigmasterol: 10.5886 mg/g Beta-sitosterol: Ranges from 963.86 ± 198.39 to 1783.37 ± 57.70 mg/g	Haslina & Eva, 2017; Tian et al., 2021
Tannins	Phlobatannins, gallotannins	-	Limmatvapirat et al., 2020
Vitamins	Vitamin C, vitamin E, vitamin K	-	Kirrella et al., 2021
Sugars	Xylose, dextrose, fructose	Sucrose (dried corn silk): 4.40 ± 0.20 mg/g Fructose (dried corn silk): 14.20 ± 0.12 mg/g Glucose (dried corn silk): 22.20 ± 1.10 mg/g	Li et al., 2019
Volatile compounds	Carvacrol, thymol, eugenol, neo-iso-3-thujanol, cis-sabinene hydrate, 6–11-oxidoacor-4-ene, citronellol, trans-pinocamphone, cis-R-terpinol, menthol.	-	Singh et al., 2023

and how it affected rat models of streptozotocin-induced diabetes. According to their findings, aqueous extract from maize silk can lessen glomerular hyperfiltration and protect rats from diabetic nephropathy brought on by STZ. CS preventive advantage against diabetic nephropathy is unrelated to its effect on hyperglycemia, as evidenced by the fact that it did not exhibit an anti-hyperglycemic effect in this animal. The inhibition of the production of Advanced Glycation End Products (AGEs) through the polyol pathway in the last stage of glycation or the increased blood flow to the kidney may be responsible for this impact. Understanding the underlying mechanisms is critical for enhancing corn silk treatment for diabetic nephropathy.

Phytochemical Property

Flavonoids are corn silk main chemical compounds, which include flavonoid glycosides, flavanols, and isoflavones. These are the most usual structural elements from the family of flavones: apigenin, luteolin, robinin, and chrysoeriol. Another study was able to identify 33 flavonoid compounds in improved corn silk via LC-MS/MS technology (Wang et al., 2024). In addition, there are organic acids that include amino organic acids, short-chain organic acids and long-chain organic acids that are present in maize silk. In Maize Silk, the research revealed 16 different organic acids that are present in the area. Glutamic and aspartic acids are the most common, followed by four critical amino acids: these include leucine, phenylalanine, threonine, and valine.

Corn silk has been scientifically shown to greatly reduce intrahepatic cholestatic disease of the liver and effectively prevent the progression of liver fibrosis [Table 2 (Chen et al., 2012)]. Jin et al. (2022) revealed that the total flavonoids derived from corn silk at 300 and 600 mg / kg is beneficial in protecting the liver and decreasing fat vacuoles. In another study, the authors reported that total flavonoids from CS at doses of 50 mg/kg and 100 mg/kg alleviated liver injury in rats with carbon tetrachloride induced chronic liver damage. This medication significantly reduced the concentration of AST, ALT, and HA in the serum of rats with liver injury, decreased

Table 2. Effect of Corn Silk on Different Diseases

Chronic disease	Research article results	Reference
Diabetes	Treatment using polysaccharide extract of corn silk reduced alloxan-induced diabetes.	Zang et al., 2013
	Corn silk extract treatment boosted insulin levels and repaired damaged β-cells, improving glycemic control.	Guo et al., 2009
	The medication also reduced serum lipid levels (total cholesterol and triglycerides) and blood glucose levels, which were much lower.	Zhao et al., 2012
	Corn silk polysaccharide D3 protected diabetic rats' kidneys from injury by inhibiting TGF-β1 expression and reducing macrophage activity.	Wen et al., 2015
Complication of diabetes	The aqueous extract of corn silk successfully slowed the growth of diabetic glomerulosclerosis in rats with diabetes.	Suzuki et al., 2005
	Corn silk in breds with high phenol levels inhibited non-enzymatic glycation in vitro.	Faris et al., 2008
Antioxidant activity	Corn silk lavone glycosides displayed antioxidant activity and were excellent free radical scavengers.	Ren et al., 2013
	Corn silk flavonoids increased exercise tolerance in mice by increasing antioxidant enzyme levels, inhibiting lipid peroxidation, and reducing oxidative stress.	Hu & Deng, 2011
	Corn silk flavonoids dramatically reduced MDA levels, boosted T-SOD activity in serum, lowered PC levels, and raised GSH content in liver tissue.	Peng et al., 2015
	The ethanol extract of corn silks showed an inhibitory effect against oxidative stress, which could be attributed to Nrf2 overexpression.	Bai et al., 2010

Table 3. The presence of different phytochemicals in different extracts of Corn Silk

Phytochemicals	Extracts			
	80% Ethanol	Methanol	Acetone	Aqueous
Phenols	+	+	+	+
Flavonoids	+	+	+	+
Tannins	+	+	+	+
Saponins	+	+	-	+
Alkaloids	+	+	+	+
Terpenoids	+	+	+	-
Phlobatannins	+	+	-	+
Sterols	+	+	+	+
Protein xanthoproteic	+	+	+	+
Cardiac glycosides	+	+	+	+

the level of MDA in the serum and the liver tissue, and increased the activity of SOD (Jing & Hu, 2011).

The network pharmacological analysis shows that flavonoids in corn silk alleviate kidney injury through regulating the expression of inflammatory mediators. Luteolin and other flavonoids have a significant and moderate effect on key targets including HIF, AKT, and PHD as well as modulating the key signaling pathways involved in hypoxia-inducible factor 1, phosphatidylinositol 3-kinase/Akt, tumor necrosis factor-alpha, and interleukin-17. This modulation results in their usefulness in treating chronic glomerulonephritis according to Yu et al., (2020).

Khanpour & Modarresi (2017) identified allantoin using LC-MS/MS analysis. Allantoin, which is used to cure skin cancer and accelerate wound healing, has anti-inflammatory, anti-oxidant, and anti-cancer properties. Additionally, the antioxidant and anticancer compound limonene was identified (Lee et al., 2010; Jung et al., 2015).

Jung et al. (2015) isolated the flavonoid catechin from maize silk and discovered its anticancer effects. It has been established that CS possesses several biological qualities in addition to its antioxidant activity and antimutagenic action (Apampa & Adedapo, 2024). Caffeic acid, ferulic acid (Bento et al., 2018), citric acid (Zilic et al., 2016), and corn silk extracts (Huang et al., 2013) with the IUPAC name (E)-3-(4-hydroxy-3-methoxy-phenyl) prop-2-enoic acid was demonstrated to possess antioxidant qualities, anticarcinogenic activity, and antimutagenic potential. Additionally, according to studies by Kumar and Pruthi (2014) and Mancuso and San Tangelo (2014), CS offers direct or indirect hepatoprotective advantages, antithrombotic qualities, cholesterol reduction, and enhanced sperm viability. The human body can readily absorb and digest corn silk because it is a phenolic acid with minimal toxicity. Ferulate is a polysaccharide derived from either biological or chemical processes that has a high concentration of ferulic acid. One possible way to produce ferulic acid is to extract it from plant cell wall components (Mancuso & San Tangelo, 2014).

Antimicrobial Potential

Doctors, dietitians, and biologists have always been fascinated by substances possessing potent antibacterial properties. They attempt to lower the risk of illnesses from dangerous microorganisms that threaten people's health, such as bacteria, fungi, viruses, and parasites (Shankaranarayana et al., 2024). Plant extracts are essential because they are a source of several therapeutic chemicals, including antibacterial agents (Raji et al., 2019).

Besides its numerous health advantages, Corn Silk possesses strong antibacterial properties against various microorganisms. Its ability to inhibit microbial strains has been the subject of multiple investigations (Naeem, 2022). Through phytochemical analysis, corn silk extracts were found to contain substances such as tannins, steroids, flavonoids, and saponins, all of which have been shown to have antibacterial qualities (Odelola et al., 2023). Shankaranarayana et al. (2024) studied the presence of different phytochemicals in various organic solvents, as given in Table 3.

Plant extracts, specifically corn silk extract, work by targeting the cytoplasmic membrane, causing various disruptions to its permeability, functioning, and structural integrity. In addition, certain phytochemicals can prevent the creation of cell walls, biofilm, microbial DNA replication, or energy synthesis (Fig. 2). Some phytochemicals can even cause the microbe to produce reactive oxygen species (Marok et al., 2024). The 80 % ethanolic extract of corn silk had the highest zone of inhibition against bacteria such as Bacillus subtilis, Staphylococcus aureus, and Streptococcus pyogenes (Abirami et al., 2021). When compared to the methanol extract of maize silk, some moderate antibacterial and fungicidal effects against the above-studied microorganisms were observed. However, the aqueous and acetone extracts exhibited mild inhibition against none of the tested microorganisms (Shankaranarayana et al., 2024). The antibacterial activity of ethanolic extract of corn silk at varying concentrations (10 to 100%) against three bacteria associated with acne: Staphylococcus aureus, Staphylococcus epidermidis, and Propionibacterium acnes. On the same note, the outcome revealed that as the doses intensify, the antibacterial activity of S. aureus compounds declines while those of P. acnes and S. epidermis enhance. It has also been found that the ethanolic extract of Corn Silk reduces the growth of Pseudomonas aeruginosa and Staphylococcus aureus, which are two bacteria that are known to frequently cause gastrointestinal, respiratory, and urinary tract infections (Marok et al., 2024). The optimal antibacterial and antifungal activity of ethanol corn silk extract was determined against Aspergillus Niger and Aspergillus Brasiliense's. Their potency revealed a 75% decrease in nitric oxide and a 67% decrease in amylase (Abirami et al., 2021).

Antioxidant Potential

Corn silk also has antioxidant activity attributed to flavonoids, which is advantageous to health because of their variable conjugation and different quantities of hydroxyl groups in their chemical structure (Lapčík et al., 2023). Due to its high level of flavonoids and phenolic compounds, corn silk has a strong antioxidant potential and improves the ability to scavenge dangerous free radicals. Corn silk modifies several signaling cascades, which control cell death, thereby assisting the nervous system (Marok et al., 2024).

Ten distinct genotypes of maize silk demonstrated a high concentration of bioactive elements, such as phenolics and flavonoids, and the polysaccharide antioxidant properties of maize silk (Singh et al., 2022). These substances benefit humans by reducing oxidation processes and diseases resulting from oxidative stress. The evidence highlighted in the article shows that high phenolic and other antioxidant chemicals

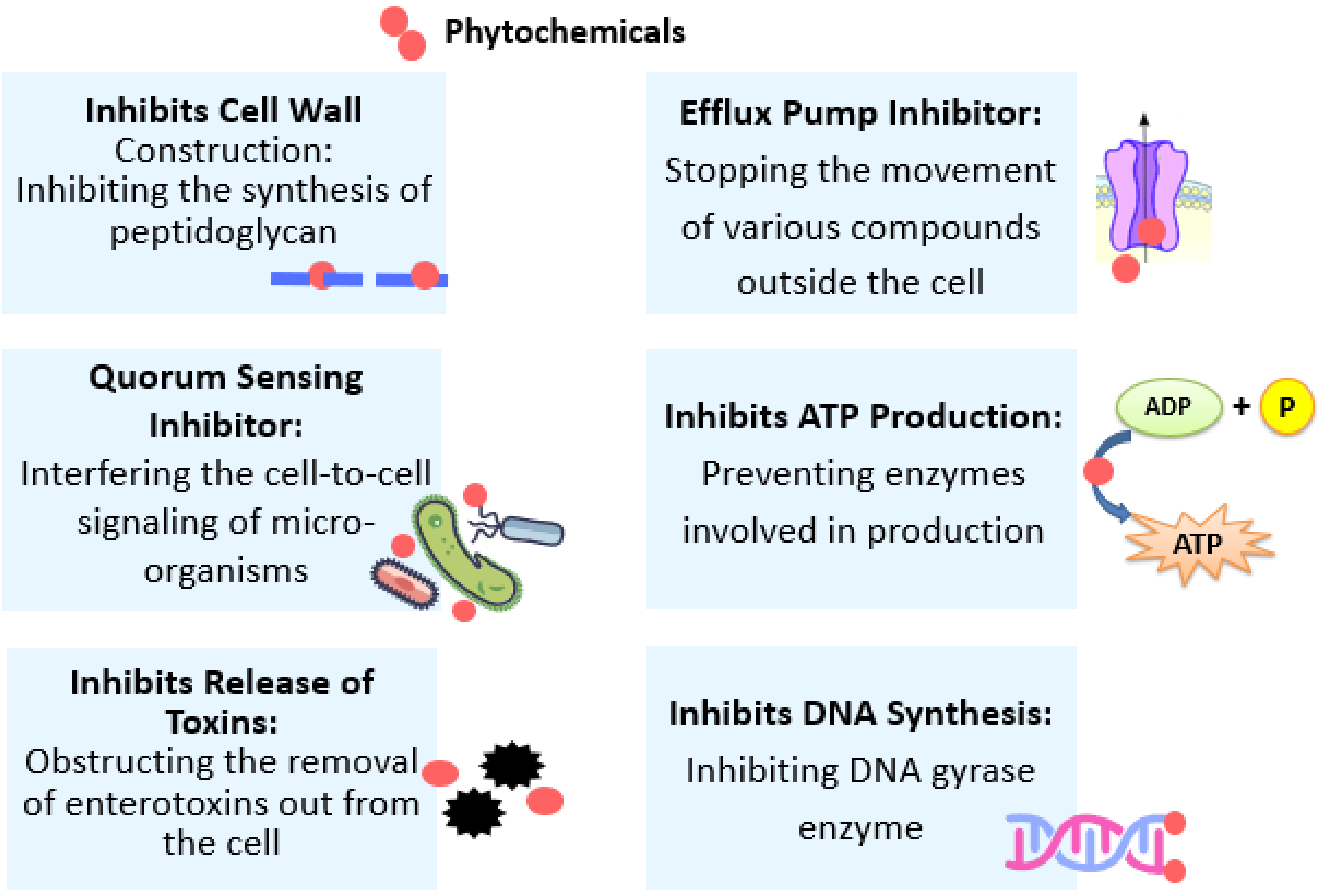

Fig 2. Antimicrobial mechanism of specific bioactive compounds that are found in Corn Silk

containing foods reduce the risk of chronic diseases, cancer, and cardiovascular diseases. Bioactive substances possess antioxidant properties via multiple mechanisms: Inhibition of oxidizing enzymes, free radical scavenging activity, and transition are used to maintain lipid peroxidation. (Wang et al., 2023). Some chemical compounds are physiologically active that are also associated with the antioxidant properties differently during the maturity of corn silk. The ecological, agronomic, and biological connections have also an impact on the content and quantity of bioactive compounds existing in maize silk (Lapčík et al., 2023)

The regression of oxidative stress via the flavonoids in corn silk is fundamentally due to its modulation of free radical generation and elimination of free radicals. For determining the antioxidant activity of a 70% acetone-water extract of corn silk, the ferric reducing antioxidant power (FRAP) test was done which shows a positive correlation between the total polyphenol content and the antioxidant activity of corn silk extract (Tian et al., 2021). Due to the antioxidant activity in corn silk extracts, there are enormous potentialities for potentials treatment medications for diseases like hypertension, diabetes, and nephritis. Other phytochemical properties of corn silk that can guard against diseases include flavonoids, phenolics, terpenoids, tannins, sterols, and alkaloids since they have antioxidant activity that reduces blood sugar in diabetic patients (Singh et al., 2022).

It has revealed various biological activities such as anti-inflammatory, neuroprotective and antioxidant activities. The experiment on the stem plank of flavond & flavonol on tyrosinase inhibition, and antioxidation, creates a window to mark potentially responsive natural antioxidants from corn silk (Wang et al., 2022).

Anti-Cancer Nature

The polyphenols, flavonoids, and sterols of corn silk are also known for their anticancer activity. Corn silk flavonoids have anti-inflammatory effects which also act on inflammatory factors and modulate the immunological response associated with T cells. As stated before, the quality compounds present in corn silk can reduce the adverse effects of cancer treatment. Bioactive compounds present in corn silk like rutin and quercetin decrease the renal toxicity of chemotherapeutic agents. Moreover, this work implies that corn silk can have an additional effect as an anti-carcinogenic agent since it acts as a modulator of tumor control and inhibits metastasis (Gulati et al., 2023).

Polysaccharides, also referred to as biomacromolecules, have been extended to be used in the aspect of biological functions including antioxidant effect, immunomodulation, and anti-cancer properties (Li et al., 2020). Corn silk polysaccharide extract has the potential to promote blood coagulation and has immunological and anti-lung carcinoma properties. Hence, it is a new immunological chemical candidate for the prevention of bleeding in cancer (Zhu et al., 2024). The polyphenol content and antioxidant activity in corn silk may be due to ferulic acid, chlorogenic acid, caffeic acid, apigenin, and pelargonidin, with apigenin having demonstrated the ability to inhibit pancreatic cancer cell proliferation, regulate lipid and glucose levels and improve vascular function in patients with type 2 diabetes according to Singh et al (2023). Caffeic acid present in corn silk has anti-hepatocellular carcinoma activities, while Chitosan and Gallic acid are also present, which have antineoplastic activities, among other beneficial properties. Corn silk can also lessen some chemicals that cause cancer and prevent some bacteria from adhering to cell linings. In addition to this, corn silk contains other compounds such as gallic acid and chitosan, which are known to possess anti-tumorous and anti-hepatocellular carcinoma properties. Also, corn silk can lower certain carcinogens thus, it has high medicinal values due to the fact that it possesses several bioactive phytochemical compounds (Apampa & Adedapo 2024).

TOXICITY OF CORN SILK AND SAFE DOSE

How your body responds to corn silk supplements may depend on several factors, such as your age, health, and medical history. According to most studies, corn silk is safe for most persons to consume in daily quantities of up to 4.5 grams per pound of body weight (10 grams per kg). However, the majority of corn silk supplement labels advise far smaller dosages of 400–450 mg taken twice or three times per day. To make sure your body reacts well, it is advised to start with a modest dose and raise it gradually if needed. Moreover, corn silk has been proven nontoxic (Hasanudin et al., 2012). According to another study, no anomalies are associated with the 500 mg/kg dose of corn silk extract. It was discovered that a corn silk extract could have a maximum non-toxic dose of more than 500 mg/kg (Ha et al., 2018).

UTILIZATION OF CORN SILK IN THE FOOD INDUSTRY

Corn silk, the thread-like fibers found on corn ears, has attracted attention in the food industry for its potential functional properties and nutritional benefits. Here are the main ways corn silk is used in the food industry;

Nutraceutical and Functional food

Corn silk is a medicinal plant due to its Nutraceutical potential to treat various diseases in traditional Chinese medicine. Hypotensive, glycemic, antidepressant, anti-fatigue, and hypolipidemic properties of corn silk have been widely documented. Furthermore, in a novel research, the soothing properties of corn silk were explored in mice. They were carried out using sleep induced models by caffeine and phenobarbital. They were found to minimize sleep response time and maximize sleep span in both models of sleep disruption. The study also investigated the mechanism of sedative action. It revealed that beta-sitosterol is responsible for enhancing the expression of melatonin receptors 1 and 2, which helps decrease sleep response time and promote good span of sleep (Kim et al., 2022). corn silk has excellent tendency as a functional food, and its composition is mentioned below;

Corn silk has been widely utilized in the treatment of cystitis, gout, and nephrolithiasis. The diuretic properties of corn silk make it a suitable organic remedy to treat hypertension; hence, corn silk tea is widely used to treat patients with high blood pressure. Furthermore, Korea, Japan, China, the United States, and the United Kingdom have turned this byproduct into a valuable functional food in the form of tea, flavoring agents, and nutritional additives to improve the texture and appearance of beef cutlet and cosmetics. Supplements of corn silk present remarkable health benefits, including hypotensive properties, anti-inflammatory in the prostate, anti-diabetic, cystitis, edema, obesity, and as a relaxant (Samee et al., 2023).

Wahjuningsih (2020) reported the antilipidemic properties of corn silk, which are mainly carried out by decreasing cholesterol absorption in the bloodstream by beta-sitosterol, which has a similar structure to cholesterol. Water extract of CS has also been found to suppress advanced glycation end products (AGEs), responsible for aging and several complications of diabetes, like nephropathy, retinopathy, and neuropathy. Hence, it is used in China and Japan to prevent complications of diabetes and to treat edema (Sano, 2022).

Source of Dietary Fiber

Dietary fiber is a component of plant-based carbohydrates that is difficult to digest and absorb in the human digestive system. Fresh corn silk contains 17.2% total dietary fiber, whereas dried corn silk has 54%. Therefore, it can potentially be used as an ingredient in fibrous food. When corn silk fiber is utilized to substitute 15% of wheat flour in cakes, it increases the volume of the cake as compared to the control. Nutrition labeling regulation has considered fibrous cake products as a source of dietary fiber (Kulapichitr et al., 2015).

Rozan and colleagues (2022), in a recent study, compared the corn silk powder (CSP) with durum wheat semolina (DWS) for its nutritional value by adding it to pasta and found that CSP contains higher amounts of mineral elements, protein, oil, ash, fiber and less carbohydrate content as compared to DWS. The study found a notable boost in protein, ash, and fiber in the pasta after adding CSP, these results have supported the corn silk to be specified as a food additive. In another study, wheat flour was replaced by CSP to prepare muffins at 10%, 20%, 30%, and 40% levels, with the increase in the percentage of CSP, fiber content, and protein increases in muffins. At 40% replacement level of CSP with wheat flour antioxidant activity and phenolic profile of muffins also increased, which makes it a healthy alternative to be used in bakery products, infant foods, instant mixes, and other valuable food items (Paich et al., 2024). CSP is also incorporated into yeast bread, increasing its total dietary fiber, protein, and firmness while decreasing visual acceptability. It is also used in butter biscuits, which show improved nutrition and functional properties compared to wheat biscuits.

Potential for Functional Drinks

Functional drinks are beverages designed to serve two primary purposes: nutritional benefits and sensory enjoyment, like a pleasant texture and great taste (Salsabila et al., 2021). Corn silk is abundant in several minerals: Ca, K, Mg, Na, essential oils, alkaloids, saponins, tannins, and flavonoids, vitamins B, C, K, fiber, protein, carbohydrate, steroids, and polyphenolic compounds as a functional drink in the form of corn silk milk for patients of diabetes, high cholesterol and those who are on a diet (Linawati & Kusumaningtias, 2023). Corn silk is rich in flavonoids, which stimulate insulin by activating pancreatic beta-cells and help decrease blood sugar levels. Corn silk tea has 0.03% flavonoids (Shalihah et al., 2020) and is consumed widely to lower blood sugar levels in diabetes patients. Another study on male rats found the potential of corn silk drinks to reduce blood pressure in hypertensive patients. Corn silk infusion has historically been used as a medicinal cure for various diseases, including urinary bladder and prostate inflammation and urinary system irritation.

Today, there are many commercially available traditional products made from CS. Additionally, corn silk infusion is believed to help alleviate prostate issues, nocturnal enuresis, median nerve compression, edema, and obesity. It is also helpful to reduce premenstrual syndrome symptoms and promote overall relaxation. CS is also documented to be effective in treating urinary tract infections and cystitis, and it may help with polyuria and further urinary issues related to urinary bladder and urethral walls irritation and prostate issues. Furthermore, it is also helpful in soothing and relaxing the internal walls of the urinary bladder and tubules, relieving urinary tract irritation and ameliorating urinary excretion.

CONCLUSION

Corn silk, which is a part of corn plant and obtained during its cultivation, has shown potential in various bioactive properties. This chapter sought to establish the therapeutic and nutritional value of corn silk, with its anti-diabetic, phytochemical, antioxidant and antimicrobial properties. Phytochemical constituents of corn silk include flavonoids, alkaloids and tannins which mainly give the plant its properties such as glycemic control, antioxidant activity and antimicrobial activity. Compared to animal and human research studies, corn silk has been proven to help regulate blood sugar levels in diabetic individuals based on its ability to regulate insulin sensitivity, glucose uptake and inflammation. Moreover, its great antioxidant activity can be effective in the response to oxidative stress in chronic diseases. Corn silk also provides antimicrobial properties against pathogenic microbes, which add to the medical values of consuming corn silk in order to improve health conditions. Nevertheless, studies reveal the need for more detailed studies on the mode of action, the method of extracting bioactive compounds from corn silk, and safety evaluation of prolonged use of corn silk. The use of corn silk in diet and medicinal products could afford sustainable solutions to complications of diabetes and associated conditions. Therefore, corn silk is a viable, renewable material with great medicinal properties. Furthering knowledge on its active constituents and therapeutic potentials will open up opportunities for new approaches in managing diseases, affirming the place of nature-based treatments in contemporary medicine.

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