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Stigma maydis: a concise overview on corn silk as potential therapeutic agent

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Corn silk has long been viewed as a waste item, but it has recently gained popularity in Asian and African countries owing to its numerous health-promoting properties. Many maize silk-derived extracts and bioactive components, for example, have been shown to have antidiabetic, antihyperlipidaemic, anticancer, antihepatotoxicity, antinephrotoxicity, and antimicrobial properties. Furthermore, numerous studies have shown that corn silk contains a variety of bioactive substances such as proteins, carbohydrates, vitamins, minerals, fixed and volatile oils, steroids, flavonoids, and phenolic compounds, which may be responsible for the potential health benefits. The antioxidant, antibacterial, and antiproliferative actions of ethanol extracts of maize silk have been found to be effective due to the presence of numerous bioactive components. Maysin derived from maize silk extract contains luteolin, a physiologically active chemical with antioxidant and anticancer properties. This review will primarily examine various experimental reports of *in vitro* and *in vivo* studies to highlight the potential health benefits of corn silk against various diseases.

Keywords: Stigma maydis, therapeutic, corn silk, antidiabetic, antihyperlipidaemic, anticancer, antihepatotoxicity, antinephrotoxicity, antimicrobial properties

1. Introduction

Corn silk (**Figure 1**), the major by-product obtained after corn processing, is collected in large quantities and dumped as an agricultural waste. Corn silk, scientifically known as Stigma Maydis, has a morphological characteristic of thread-like structures inter-linked with the ear of corn (1).

With an annual production of 30 million tons (2020–2021) and a global production of 1,148 million tons, maize is the third most popular crop in India. Corn makes up 10% of the nation's total grain supply and is used in a wide range of industrial processes to make starch, protein, sweeteners, extruded goods, textiles, gum, medicines, and paper. Due to a lack of proper utilization, the main by-product of corn processing is corn silk, which is typically collected at a rate of 123–283 kg/ha and utilized as manure, agricultural trash, or animal feed (1).

It has been recognized as a great source of certain volatile and fixed oils, alkaloids, saponins, cetosterol, stigmasterol, and several natural antioxidants. According to reports, nations including China, Turkey, the United States, and France employ maize silk as the best natural alternative to pharmaceuticals and as a therapeutic treatment for a variety of health conditions (2).

Since it is more widely accepted culturally, has greater compatibility with the human body, and has fewer side effects, herbal therapy is the foundation of primary healthcare. Due to its numerous therapeutic characteristics, Resha-e-Makka (Zea mays) is a significant medicinal plant in the Unani system of medicine (USM). The antibacterial, antimicrobial, anti-depressants, anti-diabetic, hypolipidemic, antioxidant, hepatoprotective, antimalarial, antipyretic, analgesic, anti-inflammatory, anti-cancer, etc. action of Zea mays is well known. There are various marketed products of corn silk (**Figure 2**).

2. Plant overview (1, 3, 4)

Zea mays Linnaeus, often referred to as maize, is a plant that belongs to the Poaceae or Gramineae family. It is native

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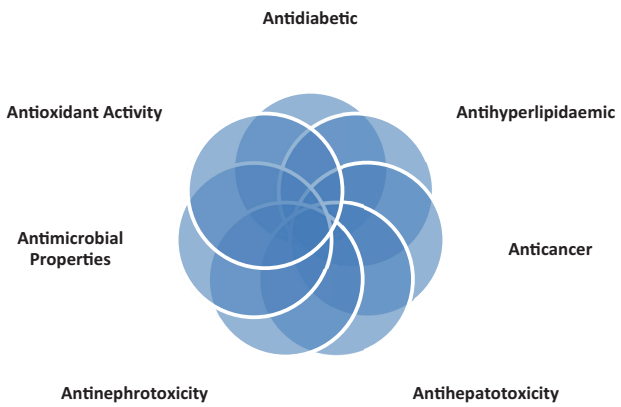
FIGURE 1 | Corn silk.

FIGURE 2 | Different marketed product of corn silk.

to Mesoamerica and spread over the American continents after being domesticated in Mexico around 9,000 years ago. It is now widely grown around the world. Ten thousand species of local maize are found in 600–700 distinct genera; this family also contains rice, wheat, oats, and barley. Corn is used in all its components, even the silks. Corn flowers are monoecious, meaning that the male and female flowers grow on the same stalk in separate inflorescences. Yellow pollen is produced by the male flowers (tassels) at the top of the plant. In the meantime, the female flowers, which are found on the leaf axils, generate Corn silk. The silks resemble tufts of hair because they are elongated stigmas. Corn silk first appears pale green in most cases before changing to red, yellow, or light brown. Pollen is captured by corn silk in order to facilitate pollination. One maize kernel may be produced by pollinating each silk (1, 3, 4). The corn silk has a somewhat sweet flavor and may reach lengths of up to 30 cm. Just before pollination, corn silk

is picked for medicinal purposes. It can be used either fresh or dried.

3. Various pharmacological activity of corn silk (1, 5, 6)



3.1. Antidiabetic

Conventional antidiabetic medications can alter a number of glucose metabolic processes, including insulin secretion and target organs' uptake of glucose and their absorption of nutrients corn silk has been found to have a positive impact on glycemic metabolism through increased secretion of insulin, whereby the increase in Recovery of β-cells and insulin level were known to be the potential methods by which corn silk regulates high blood sugar. In an earlier study, daily 100–500 mg/kg of body weight corn silk was treated. A polysaccharide's antidiabetic impact was found in diabetic rats produced by streptozotocin by lowering blood serum lipid profile and glucose level. Additionally, the polysaccharide from maize silk enhanced the diabetic rats' ability to tolerate glucose, according to the oral glucose tolerance test (OGTT) Furthermore; corn silk polysaccharides have the ability to lessen the amount of body weight lost, lower blood sugar levels, boost the production of serum insulin and restore glucose insensitivity in mice with type 2 diabetes.

In a different study, 250, 500, and 750 mg/kg of the methanol extract from corn silk in diabetic mice reduced the increased blood sugar levels that were dose-dependent with the most effective dosages being 500 and 750 mg/kg body weight. Additionally, the impact of maize silk on the *in vitro* glucose uptake by a rat hemi-diaphragm isolated showed that corn silk had a direct peripheral effect on glucose uptake and suggests that it works better than insulin. Apart from its impact on glucose absorption, corn silk inhibits α-amylase activity, reduces the rate at which starch is absorbed, and limits the rise in blood sugar following a meal. Similarly, maize silk controls and suppresses α-glucosidase activity. Improving glucose metabolism by focusing on signal pathways that enhances glucose metabolism and insulin activity (1, 7).

3.2. Antihyperlipidaemic

Hyperlipidemia is the term used to describe the increase in the levels of plasma lipids such as triacylglycerols (TG), total cholesterols (TC), cholesterol esters, and phospholipids. Prior research revealed that administering flavonoid therapy to hyperlipidemic rats from maize silk extract in varying amounts (200, 400, and 800 mg/kg) for 20 days decreased the levels of TC, TG, and LDL-c, although No variation in HDL-c was seen among the three dosage groups. However, a related investigation indicated that the antihyperlipidemic effects of flavonoids from maize silk were achieved by a decrease in serum concentration of TC, TG, and LDL-c as well as elevated serum in a mouse model, HDL-c concentration, indicating that corn flavonoids Silk extract may be able to reduce hyperlipidemia and inhibit the development of atherosclerosis. Furthermore, a major risk factor connected to atherosclerosis (AS) and coronary heart disease (CHD) is hyperlipoproteinemia. The main defenses against AS and CHD include modulation and mitigate the negative consequences of hyperlipoproteinemia. The effects of total corn silk total flavonoid (CSTF) affects lipoprotein cholesterol and cholesterol metabolism in rats with high cholesterol also showed comparable decreases in the atherogenic markers LDL-c, TC, and TG raise the level of HDL-c, or non-atherogenic lipoprotein. Recent reports suggest that maize silk aqueous extract has an antihypertensive impact in addition to an antihyperlipidemic effect via lowering blood pressure. Additionally, an eight-week administration of maysin, a bioactive component derived from corn silk, to rats that were obese due to a high-fat diet showed a notable decrease in the weights of their kidneys, epididymal fat, and bodies, proving that maysin has a decreasing effect on weight by reducing the body's formation of fat.

Using an alloxan-induced hyperglycemia in mouse model, the study examined the effects of CS aqueous extract (0.5, 1.0, 2.0, and 4.0 g/kg body weight) on glycemic metabolism. Saline was used as the control while Xiaoke tablets, a Chinese diabetic medication, served as the positive control.

3.3. Anticancer

Maysin, a kind of flavonoid unique to maize, is present in significant amounts in corn silk extract. Maysin contains luteolin, a chemical that is physiologically active and has antioxidant and actions against cancer. Prior research on Maysin has shown anti-inflammatory and anti-oxidant properties, and effects against cancer. Furthermore,

through antioxidative and anti-apoptotic mechanisms, maysin extracted from maize silk has a neuroprotective impact. Furthermore, it was demonstrated that corn silk polysaccharide boosts anticancer activity by boosting immune potential as well as anti-inflammatory properties.

3.4. Antihepatotoxicity

It has been suggested that maize silk extract modulates liver disorders via lowering lipid peroxidation. For example, corn silk hydro-alcoholic extract showed the ability to prevent histological alterations in liver tissues that are dose-dependent through reduced lipid peroxidation.

3.5. Antinephrotoxicity

Urinary tract infections and kidney stones have been treated with corn silk as a diuretic agent. A previous study found that the treatment of corn silk combination (Anredera cordifolia) and corn silk extract improved increased urea, creatinine, and organ-to-body ratio (kidney) in the serum renal histopathology Moreover, the therapy seems to lower lipid renal oxidative stress by reducing peroxidation there and boosting the activity of protective enzymes such as SOD and improves kidney performance. Another study of nephrotoxicity decrease in gentamicin-induced Nephrotoxicity in mice suggested that the extract from corn silk given for 8 days alleviates nephropathy.

3.6. Antimicrobial properties

In reality, a number of investigations have shown that various solvent extracts of maize silk shown antibacterial properties. Corn silk's aqueous extract exhibited antibacterial action against microorganisms, including *B. subtilis* and *S. aureus*, with minimal 500 mg/ml and 62.5 mg/ml inhibitory concentrations (MIC) in that order. This investigation reveals the truth that corn silk extracts exhibited greater efficacy against gram-positive as opposed to gram-negative bacteria. Therefore, in addition to its antibacterial properties, maize silk aqueous extract was also found to have antifungal properties against *Candida albicans*.

3.7. Antioxidant activity

Aerobic organisms utilize antioxidants to stop oxidation, which may harm cells during oxygen metabolism. The most recent research has shown that CS extracts have the potential to serve as a significant bioactive source of natural antioxidants. *In vitro* antioxidant models were used to examine five CS fractions: ethanol extract (EF), petroleum ether fraction (PF), acetic ether fraction (AF), n-butanol fraction (BF), and water fraction (WF). The maximum total phenolic (164.1 g GAE/g DCS) and total flavonoid content was found in the BF fraction (100 g/mL) of the sample. When compared to other CS fractions, BF showed the strongest antioxidant activity. At 100 g/mL, BF had the highest total antioxidant (0.789) and reducing power (1.242), while at 120 g/mL, BF had the highest radical scavenging activity (72.93%) and iron-chelating activity (62.06%). These antioxidant levels were equivalent to those of ethylene diamine tetra acetic acid (EDTA) and vitamin C (a positive control). In a different antioxidant investigation, the findings of the CS ethanol extract were equivalent to those of vitamin C ($p > 0.05$) and showed strong reducing power at doses of 0.8 and 1.6 mg/mL. As a result, the extract could act as an electron donor, stopping the chain reactions caused by free radicals.

4. Prospective outlooks and summary

Growing consumer health consciousness and a significant movement toward natural goods are boosting the maize silk industry. Corn silk is rich in nutrients and bioactive substances while being regarded as trash. The current analysis emphasizes the nutritional makeup of various maize varieties that are grown across the world as well as their bioactive potential (5).

The bioactive components of corn silk are abundant and encourage the use of maize silk in both the food and non-food industries, such as the pharmaceutical, cosmetic, and medicine, as well as the animal feed industries.

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