CORN SILK FROM WASTE MATERIAL TO POTENTIAL THERAPEUTIC AGENT: A MINI REVIEW

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Abstract: Corn silk is traditionally regarded as waste material, however recently is gaining much interest in Asian and African countries particularly due to its several health promoting effects. For instance, several corn silk-derived extracts and bioactive constituents have been demonstrated to exhibits antidiabetic, antihyperlipidaemic, antiobesity, anticancer, antihepatotoxicity, antinephrotoxicity and antimicrobial effects. Moreover, various studies have established that corn silk contains many bioactive compounds including proteins, carbohydrates, vitamins, minerals, fixed and volatile oils, steroids, flavonoids and phenolic compounds which perhaps are responsible for the potential health benefit reported. Most of these bioactive compounds present in corn silk exhibited antioxidant properties and confers health beneficial effects against several chronic and age-related diseases including diabetes, hypertension, cancer, hepatic and cardiovascular diseases. In view of the fact that many studies have continuously investigated the potential health benefits of corn silk which was traditionally regarded as waste material, the present review principally examine various experimental reports *in vitro* and *in vivo* studies using PubMed and reputable indexed journals to highlights the potential health benefits of corn silk against chronic and age-linked diseases.

Keywords: Corn silk, antihyperlipidemic, antidiabetic, antioxidant, therapeutic agent

Introduction

Corn silk (*Stigma maydis*) refers to the stigmas originated from the female flowers of corn, and a fresh corn silk resemble soft silk threads of about 10 – 20 cm long that are either light green or yellow-brown in color (Guo *et al.*, 2009). Corn silk contains maizeric acid, resin, sugar, mucilage, fibres that are essential for human diet (Nurhanan & Rosli, 2014). In addition, corn silk contains chemicals that act as water pills (diuretics), alter blood sugar levels and also help in reducing inflammatory response (Gwendin *et al.*, 2015). Moreover, corn silk contains many essential bioactive compounds which include proteins, vitamins and minerals (Hu & Deng, 2011; Ren *et al.*, 2013; Bhuvaneshwari & Sridevi, 2015; Zilic *et al.*, 2016), carbohydrates, fixed and volatile oils, steroids and other natural antioxidants like flavonoids (Vijitha & Saranya, 2017). Furthermore, corn silk is an excellent source of many phenolic compounds with potential health promoting effects (Liu *et al.*, 2011).

Corn silk is used traditionally for making tea as a healthy and medical drink by Asian communities especially in China (Cuina *et al.*, 2011). The phytochemicals present in corn silk have antioxidant properties and thus could have beneficial effects in humans (Hasanudin *et al.*, 2012). Therefore, it can be used as dietary fibre and as a food additive for the prevention of several chronic diseases (Hasanudin *et al.*, 2012). In China, for instance, corn silk is well known as an important traditional Chinese medicine in treating several illnesses related to kidney (Zhao *et al.*, 2012), treatment of edema, cystitis, gout, treat rheumatism, rheumatoid arthritis and exert antimicrobial effects (Amreen *et al.*, 2012; Chen *et al.*, 2013). Moreover, corn silk has been incorporated into beef patties at the doses of 2, 4 and 6% to make meat products which resulted in the improved nutrients such as protein, minerals and reduced the fat content without any change in the sensory attributes of the patties (Wanrosli *et al.*, 2011).

Interestingly, previous study using male and female rat model has demonstrated that corn silk is safe and non-toxic (Wang *et al.*, 2011). Previous study also reported that acute and sub-acute toxicity study of corn silk revealed no death or abnormal symptoms and no related toxic effect on body weight, water intake, food consumption, urine parameters, clinical chemistry, or organ weight in all treatment groups within the study period (Ha *et al.*, 2018). Similarly, corn silk extract administered to rats at dose of 100, 200, and 400 mg/kg body weight for 28 days revealed non-toxic effects in hematological parameters investigated (Saheed *et al.*, 2012). In view of the fact that many studies have continuously investigated the potential health benefits of corn silk which was traditionally regarded as waste material, the present review principally examine various experimental reports *in vitro* and *in vivo* studies using PubMed and reputable indexed journals to highlight the potential health promoting effects of corn silk against chronic and age-linked diseases with emphasis on liver and kidney diseases, antidiabetic, anticancer, antibacterial, antifungal and antiviral effects.

Antihyperlipidemic effect of corn silk extracts

Hyperlipidemia refers to the elevation of plasma lipids such as triacylglycerols (TG), total cholesterols (TC), cholesterol esters and phospholipids (Yadav *et al.*, 2019). This pathological condition plays a major role in the development of atherosclerosis and it's recognized as crucial risk factor for the onset of cardiovascular diseases (CVDs). Previous study reported that treatment of hyperlipidemic rats with flavonoid from corn silk extract at different doses (200, 400 and 800 mg/kg) for 20 days reduced TC, TG and LDL-c level, but there was no difference in HDL-c in all the three dose groups (Wu *et al.*, 2017). However, in contrast to Wu *et al.* (2017), another related study demonstrated that flavonoids from corn silk showed antihyperlipidemic activities through reduction in serum TC, TG and LDL-c, concentration and increased serum HDL-c concentration in a mice model (Zhang *et al.*, 2015) as demonstrated in Table 1, suggesting that flavonoids from corn silk extract might have antihyperlipidemic effects and could protect against atherosclerosis (Yan *et al.*, 2011). In addition, hyperlipoproteinemia is a cardinal risk factor linked to atherosclerosis (AS) and coronary heart disease (CHD), and the key mechanisms to prevent AS and CHD is to modulate and counteract the adverse effect of hyperlipoproteinemia (Yan *et al.*, 2011). The effects of corn silk total flavonoid (CSTF) on metabolism of cholesterol and lipoprotein-cholesterol in hyperlipidemic rats also revealed similar reduction in atherogenic markers (TC, TG and LDL-c) and improve non-atherogenic lipoprotein (HDL-c) level (Zhao *et al.*, 2012). Besides antihyperlipidemic effect, recently corn silk aqueous extract has been reported to lower blood pressure thereby exhibits antihypertensive effect (George & Idu, 2015;

Yulina *et al.*, 2013). Furthermore, treatment of maysin, a bioactive constituent from corn silk for eight weeks in high-fat diet-induced obesity in rats indicated significant reduction in their body weight, kidney and epididymal fat weights, demonstrating that maysin had a weight-reducing effect by decreasing fat accumulation in the body (Lee *et al.*, 2016). Also, Min *et al.* (2011) reported that administration of 100 and 400 mg/kg body weight of corn silk extract for two weeks significantly decreased body weight in mice. This data further indicated weight-reducing effect of corn silk (Min *et al.*, 2011). Fig. 1 summarizes the potential beneficial effect of corn silk against hyperlipidemia and related disorders.

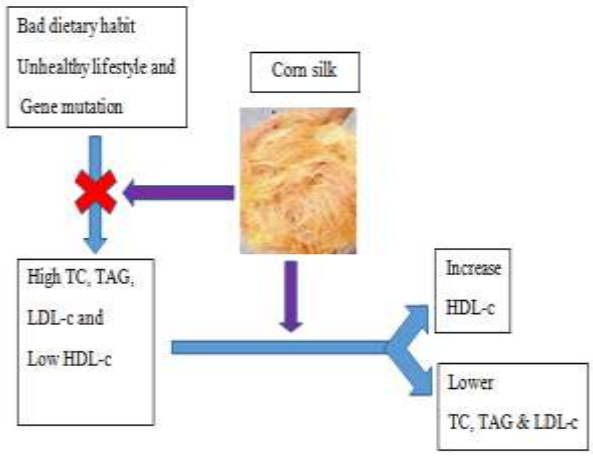

Fig. 1: Effect of corn silk extract on hyperlipidemia and cardiovascular diseases

Antidiabetic effects of corn silk extracts

Diabetes mellitus is a complex metabolic disease characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Ibrahim *et al.*, 2016). The predominant complications of diabetes are polyuria, polydypsia, polyphagia, glycosuria, blurred vision, nausea and systemic weight loss (Vijitha & Saranya, 2017). The conventional antidiabetic agents can modulate several pathways of glucose metabolism such as insulin secretion and glucose uptake by target organs as well as nutrient absorption (Ghada *et al.*, 2014). Scientifically, corn silk has been reported to exhibit beneficial effect on glycemic metabolism through enhance insulin secretion whereby the augment of insulin level and recovery of β-cells were known to be the possible mechanisms through which corn silk control hyperglycemia (Chen & Guo, 2018). In previous study, daily treatment of 100–500 mg/kg body weight of corn silk polysaccharide was linked to antidiabetic effect in streptozotocin-induced diabetic rats through decrease in blood glucose level and serum lipid profile (Table 1) (Chen & Guo, 2018). Also, oral glucose tolerance test (OGTT) in the diabetic rats showed that polysaccharide from corn silk improved glucose tolerance in diabetic rats (Chen & Guo, 2018). In addition, corn silk polysaccharides can as well reduce the body weight loss, decrease blood glucose level, increase serum insulin secretion and recover glucose intolerance in type 2 diabetic mice (Pan *et al.*, 2019). Also, in another study administration of 250, 500 and 750 mg/kg of the corn silk methanol extract to diabetic mice decreased the elevated blood glucose levels in a dose-dependent manner with 500 and 750 mg/kg body weight being most effective (Umar, 2016). Moreover, the effect of corn silk on glucose uptake by isolated rat hemi-diaphragm *in vitro* indicated that corn silk has direct peripheral action on glucose uptake and appears to be more effective than insulin (Chen *et al.*, 2013). Beside, effect on glucose uptake, corn silk inhibit α-amylase activity and slow down starch digestion rate and restrained the increase of post-meal blood sugar (Chen *et al.*, 2013). Likewise, corn silk inhibits α-glucosidase activity and regulate glucose metabolism by targeting signal pathways, enhancing insulin action and improve glucose metabolism (Chen & Guo, 2018). Thus, corn silk can be a suitable bioactive agent for the management and treatment of diabetes mellitus (Vijitha & Saranya, 2017). The antihyperglycemic and antidiabetic effect of corn silk was highlighted in Fig. 2.

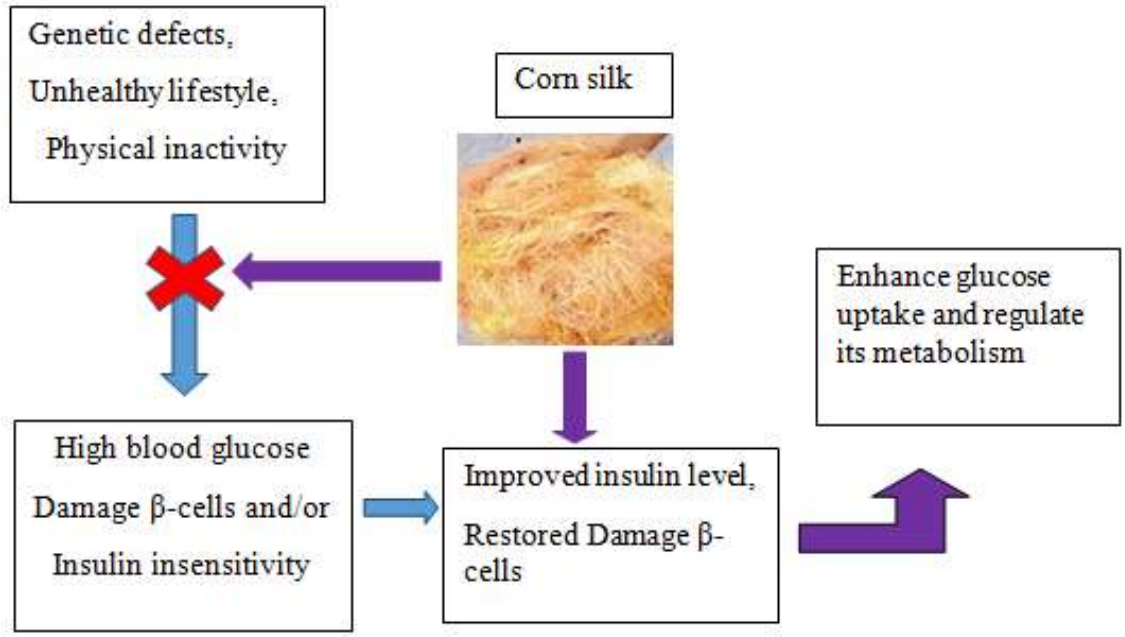

Fig. 2: Effect of corn silk extract on hyperglycemia and diabetes mellitus

Table 1: Biological effects of corn silk extracts/constituents *in vitro* and *in vivo*

Corn silk and/or bioactive components	Description of effects	Reference
Flavonoid from corn silk extract	• Reduces serum TC, TG and LDL-c level but had no effect on HDL-c.	Wu *et al.*, 2017.
Flavonoid from corn silk	• Decreases serum TC, TG and LDL-c, level and increased serum HDL-c level in a mice model.	Zhao *et al.*, 2012; Zhang *et al.*, 2015.
Flavonoid from corn silk extract	• Exhibit antihyperlipidemic effects and protect against atherosclerosis.	Yan *et al.*, 2011
Corn silk aqueous extract	• Antihypertensive effect by lowering of blood pressure	George & Idu, 2015; Yulina *et al.*, 2013.
Corn silk extract	• Enhance insulin secretion and recovery of β-cells	Chen & Guo, 2018.
Corn silk polysaccharide	• Decrease in blood glucose level in diabetic rats. • Improved glucose tolerance in diabetic rats	Chen & Guo, 2018.
Corn silk polysaccharide	• Increase serum insulin secretion and recover glucose intolerance in type 2 diabetic mice	Pan *et al.*, 2019.
	• Corn silk inhibit α-amylase activity	Chen *et al.*, 2013. Vijitha & Saranya, (2017.
Ethanol and aqueous extracts of Corn silk	• Had inhibitory effect against bacteria including *E. coli.*	Surjee & Zwain, 2015.
Aqueous extract of Corn silk	• Had antimicrobial effect against *S. aureus*, *B. subtilis* and *Candida albicans.*	Xing *et al.*, 2012.
Corn silk extract	• Ameliorated elevated serum creatinine, urea and kidney index • Reduced lipid peroxidation Increase the activity of antioxidant enzymes like SOD	Yulina *et al.*, 2013.
Corn silk extract	• Improve nephropathy • Modulate liver diseases by reduction in lipid peroxidation.	Sepehri *et al.*, 2011; Karami *et al.*, 2013.
Maysin isolated from corn silk	• Exhibits neuroprotective effect via antioxidative and anti-apoptotic mechanism.	Lee *et al.*, 2016; Bai *et al.*, 2010; Choi *et al.*, 2014; Lee *et al.*, 2014; Kan *et al.*, 2011.
Corn silk polysaccharide	• Enhances antitumor activity through increased immune capability and anti-inflammatory effects.	Yang *et al.*, 2014; Wang *et al.*, 2012.

Antimicrobial effects of corn silk extracts

Several studies have in fact established that different solvent extracts of corn silk exhibited antimicrobial activities. For instance, corn silk extracts from petroleum ether (PECS), chloroform (CECS) and methanol (MECS) and two isolated flavonoid glycosides (2 mg/ml) were investigated for antimicrobial effects (Table 1). The findings revealed that PECS, MECS and flavonoids were active against most of the gram positive and gram negative bacteria tested (Nessa *et al.*, 2012). Also previous study reported that both ethanolic and aqueous extracts of corn silk had an inhibitory effect against bacteria including *E. coli* (Surjee & Zwain, 2015). Similarly, aqueous extract of corn silk had antimicrobial activity against bacteria such as *S. aureus* and *B. subtilis* with minimum inhibitory concentration (MIC) of 500 mg/ml and 62.5 mg/ml respectively (Xing *et al.*, 2012). This study uncovers the fact that corn silk extracts were more active against the gram-positive than gram-negative bacteria. Thus, beside antibacterial activity, the antifungal effect of corn silk aqueous extract was equally reported against *Candida albicans* (Xing *et al.*, 2012). This data further established the antimicrobial effect of corn silk against pathogenic microorganism.

Effect of corn silk extract against kidney and liver diseases

Corn silk has been used as a diuretic agent for treatment of kidney stone and urinary tract diseases (Aukkanita *et al.*, 2015). Previoius study revealed that corn silk treatment of combined extract of corn silk and binahong ameliorated elevated serum creatinine, urea, organ-to-body ration (kidney index), and renal histology as shown in Table 1 (Yulina *et al.*, 2013). Furthermore, the treatment appeared to reduced lipid peroxidation there by attenuating kidney oxidative stress and increasing the activity of antioxidant enzymes like SOD and enhances renal function (Yulina *et al.*, 2013). Other nephrotoxicity reduction study on gentamicin-induced nephrotoxicity in mice indicated that corn silk extract administered for eight days improve nephropathy (Sepehri *et al.*, 2011). Conversely, corn silk extract has been reported to modulate liver diseases through reduction of lipid peroxidation. For instance, hydro-alcoholic extract of corn silk demonstrated protective effect against histopathological changes in liver tissues in a dose-dependent manner via decreased in lipid peroxidation, although other mechanisms might also be involved (Karami *et al.*, 2013).

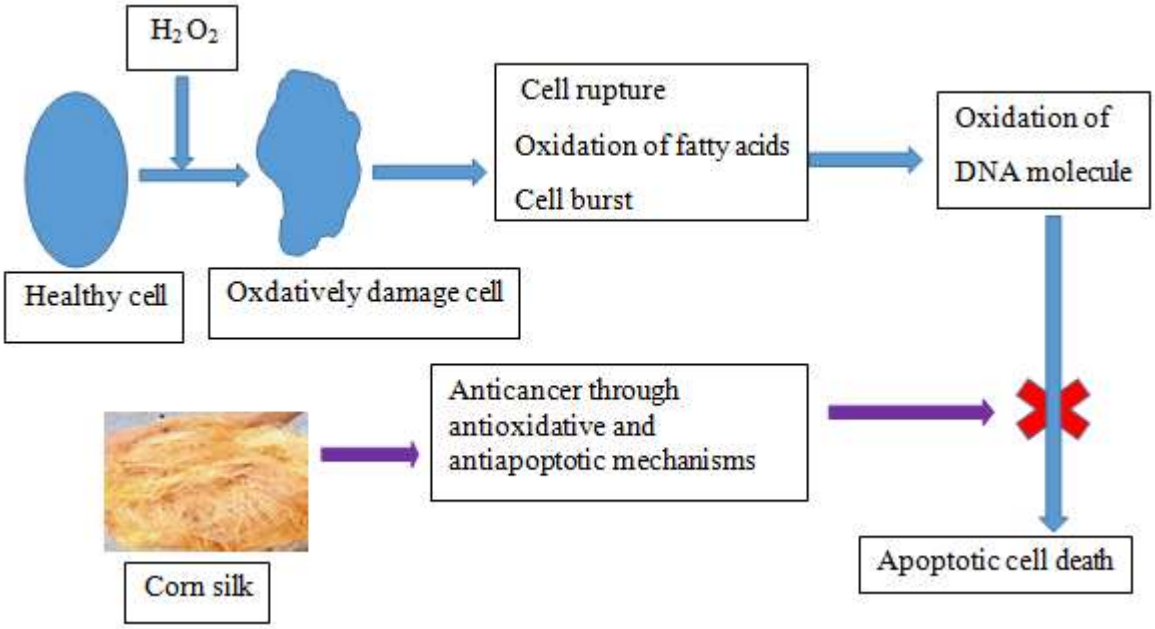

Fig. 3: Antioxidative and anticancer effect of corn silk

Anticancer effect of corn silk extract through antioxidative mechanism

Corn silk extract contains large amount of maysin, a type of flavonoid specific to corn (Fossen *et al.*, 2001; Kim *et al.*, 2001). Maysin from corn silk extract contain luteolin, a biologically active substance known to have antioxidant and anticancer activities (Lee *et al.*, 1998). Previous studies on maysin have demonstrated antioxidative, antiallergy and anticancer effects as indicated in Table 1 (Lee *et al.*, 2016; Bai *et al.*, 2010). Furthermore, maysin isolated from corn silk has a neuroprotective effect via antioxidative and anti-apoptotic mechanism (Choi *et al.*, 2014; Lee *et al.*, 2014; Kan *et al.*, 2011). In addition, corn silk polysaccharide was shown to enhance antitumor activity through increased immune capability and anti-inflammatory effects (Yang *et al.*, 2014; Wang *et al.*, 2012). The antioxidative and anticancer effect of corn silk was highlighted in Fig. 3.

Conclusion

In conclusion, several studies have demonstrated the therapeutic potential of corn silk extract which was traditionally regarded as waste material against several chronic and age-related diseases including diabetes, hyperlipidemia, cancer, cardiovascular diseases and microbial infections. Therefore, corn silk could be potential health promoting agent in humans. However, further studies are required to explore detail molecular mechanisms via which corn silk extract exhibits health beneficial effects.

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Conflict of Interest

The authors declare that they have no conflicts of interest with the contents of this article.

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