Maize Journal (October 2022) 11(2): 65-74

REVIEW PAPER

Nutritional and medicinal importance of corn silk in human health

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Abstract: Corn silk is an unique byproduct of maize which can provide countless advantages for human health and serve as a source of income. Corn silk contains many bioactive compounds including proteins, carbohydrates, vitamins, minerals, volatile oils, steroids, flavonoids alkaloids, and phenolic compounds which perhaps are responsible for the potential health benefits. Several corn silk-derived extracts and bioactive constituents have been demonstrated to exhibits antidiabetic, anti-hyperlipidaemic, anti-obesity, anticancer, anti-hepatotoxicity, anti-nephrotoxicity, antidepressant, anti-inflammatory and antimicrobial effects. Several studies have demonstrated the therapeutic potential of corn silk extract against several diseases including diabetes, cancer, obesity, Alzheimer's disease, cardiovascular diseases, kidney disease and liver diseases. The corn silk powder has potential to contribute to the alleviation of dietary nutritional deficiencies and can be utilized in preparation of various traditional and snack products to enhance their nutritive values. Corn silk can help in value addition of the products as well as provide low-cost nutritious alternatives for combating malnutrition. Use of corn silk will lead to valorization of agricultural residue via waste utilization which increases farmer income as well as reduce environmental pollution due to agricultural wastes. There is a great need to strengthen research, testing, and product development activities for the proper, effective, and safe utilization of corn silk.

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Received: 10 July 2022/ Accepted: 25 September 2022

Keywords: Agricultural wastes · Corn silk · Diseases · Healthcare · Nutritional value

Introduction

Corn *(Zea mays)* hair or commonly known as corn silk (a thread which is soft, fine, yellowish color with mild sweetish taste) is a collection of the stigmas from the female flowers of maize plant. It is a rich source of proteins, vitamins, carbohydrates, fixed and volatile oils, sitsterol, stigma sterol, alkaloids, saponins, tannins and flavonoid. It can be used as dietary fibre and as a food additive for the prevention of several chronic diseases (Hasanudin *et al.,* 2012). Corn silk is a well-known traditional herb that has been used for treatment of varied diseases such as treating obesity, weight loss, immune enhancement, anti-cancer, anti-diabetic activity, regulation of blood sugar, kidney diseases, gastrointestinal and liver diseases. (Du *et al.,* 2007). In China, 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). Decoction of the maize silk is useful for bladder problems, nausea, vomiting, and stomach complaints (Das and Karjagi, 2022). Recently Corn silk is gaining much interest in Asian and African countries particularly due to its several health promoting effects. Thus corn silk can be used for formulation of nutritious health food product as well as can useful in generation of additional income to farmers. The present review principally examine various experimental reports and highlights 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.

Nutraceutical properties of corn silk

Corn silk contains nutritional elements that are essential for human health such as carbohydrate, protein, lipids, vitamins, and minerals (Guo *et al.*, 2009). In addition to these, Corn silk contains various phytochemicals including vitamins, alkaloids, tannins and mineral salts, steroids and flavonoids as well as other volatile chemicals and phenolic compounds with potential health promoting effects (Kwag, 1999). The dried cornsilk is the richest source of protein and dietary fibre (TDF). Also it has the higher percentage of ash and total sugar content (40.60 mg/100 g *i.e*. Fructose 14.2 ± 0.12%, Glucose 22.2 ± 1.10% and Sucrose 4.40 ± 0.20%). The energy value ranged from 361 to 390 kcal/100g. The concentrations of different nutrition's, minerals, total polyphenol and flavonoid in corn silk are given in Table 1, 2 and 3 (Nurhanan and Wan Rosli, 2012 & 2013).

Corn silk is a good source of antioxidant content, which provides quality and nutritional value, as well as anti-inflammatory, antidiabetic, antiviral and antioxidant properties and are important for human fitness. These antioxidants include polyphenolic compounds, flavonoids, and ascorbates. Different sterols found in corn silk are 24-methylcholesterol, 24-ethyl-5, 22-cholestadien-3β-ol, 24-ethylcholesterol and (28Z)-24-ethylidenecholesterol (Knights and Smith, 1976). Maksimovic *et al.,* (2004) reported that corn silk extract contains a mixture of stigmasterol and sitosterol in the ratio of 4:1 and sitosteroline (β-sitosteryl-3-O-β-*D*-glucoside). Elliger *et al.,* (1980) reported a flavonoid compound that known as c-glycosylflavones was isolated from methanol extract of corn silk. Snook *et al.* (1995) isolated the compounds 2"-*O*-α-L-rhamnosyl-6-C-quinovosylluteolin, 2"-*O*-α-L-rhamnosyl-6-Cfucosylluteolin, and 2"-*O*-α-L-rhamnosyl-6-C-fucosyl-3'-methoxyluteolin from the cornsilk extracts. The flavones identified by Zhang and Xu (2007) in cornsilk (water extract) are 7-hydroxy-4'- methoxyisoflavone and 2"-O-α-L-rhamnosyl-6-C-(6-deoxy-ax-5-methyl-xylo-hexos-4-ulosyl)-3' methoxyluteolin. Two flavone glycosides, isoorientin-2-2"-O-α-L-rhamnoside and 3'-methoxymaysin, were also isolated from the ethanol extract of corn silk (Liu *et al.*, 2011). The flavonoid, 3'-methoxymaysin and reduced derivatives of maysin have been isolated and identified from corn silks of several corn inbreeds. The 3-hydroxyanthocyanins occur in almost all corn plant parts, but the 3-deoxyanthocyanins is only found in corn silk (Halbwirth *et al.,* 2003). Five other flavonoid derivatives were isolated from CS ethanol extract (80%) and identified as 2"-*O*-α-L-rhamnosyl-6-C-3"-

Table 1. Nutritional compositions of corn silk

Nutritional compounds	Corn silks	
	Immature silks	Mature silks
[1]Moisture (fresh)	89.31 ± 0.74	84.42 ± 0.65
[2]Moisture (oven-dried)	4.15 ± 0.21	3.90 ± 0.22
[2]Crude lipid	1.27 ± 0.16	0.66 ± 0.17
[2]Crude protein	12.96 ± 0.38	8.95 ± 0.21
[2]Ash (%)	5.28 ± 0.13	5.51 ± 0.24
[3]Carbohydrate	27.80 ± 2.25	29.74 ± 1.26
[2]Total dietary fiber (g/100 g)	48.50 ± 2.88	51.24 ± 1.50

[1]Moisture content determined by fresh weight.
[2]Dry basis.
[3]Calculated by difference [=100–(crude lipid + crude protein + TDF + ash + moisture)].

Table 2. Mineral contents of corn silk

Minerals level (μg/g)	Corn silks	
	Immature silk	Mature silk
Macro elements		
Calcium (Ca)	1087.08 ± 105.51	707.04 ± 94.41
Magnesium (Mg)	1219.17 ± 143.07	361.50 ± 20.53
Potassium (K)	26281.67 ± 1379.7	35671.67 ± 2466
Sodium (Na)	190.67 ± 22.61	266.67 ± 15.65
Minor elements		
Copper (Cu)	5.60 ± 0.4	4.12 ± 0.38
Iron (Fe)	2.17 ± 0.15	4.50 ± 0.49
Manganese (Mn)	32.17 ± 3.14	35.57 ± 2.26
Zinc (Zn)	46.37 ± 4.21	35.92 ± 4.24

Table 3. Total polyphenol and flavonoid content of silks from immature and mature corns

Extract	Immature silks (mean + SD)	Mature silks (mean + SD)
Total polyphenol (mg GAE/g extract)		
Water	35.35 ± 2.17	64.22 ± 2.55
Ethanol	92.21 ± 3.59	49.88 ± 2.87
Ethyl acetate	6.70 ± 0.51	4.96 ± 0.53
Total flavonoid (mg CAE/g extract)		
Water	8.40 ± 0.48	2.31 ± 0.12
Ethanol	7.55 ± 0.37	1.96 ± 0.20
Ethyl acetate	0.66 ± 0.02	2.10 ± 0.19

deoxyglucosyl-3'-methoxyluteolin, 6,4'-dihydroxy-3'-methoxyflavone-7-*O*-glucosides, ax-5"-methane-3'-methoxymaysin, ax-4"-OH-3'-methoxymaysin and 7,4'-dihidroxy-3'-methoxyflavone-2"-*O*-α-L-rhamnosyl-6-C-fucoside (Ren *et al.,* 2009). Ascorbic acid is required for a variety of physiological processes as well as acting as a powerful antioxidant in the battle against diseases caused by free radicals (Alam, 2011; Pisoschi *et al.,* 2009). The vitamin C content of corn silk powder was reported to be high as 270±0.57 mg/100 g, (Singh *et al.,* 2022) which is significantly higher than the 9.72 mg/100 g reported by El-Kewawy (2018). In addition to the above phytochemicals, corn silk contains saponins, which are characterized by their structure containing a triterpene or steroid aglycone and one or more sugar chains. Consumer demand for natural products coupled with their physicochemical (surfactant) properties and mounting evidence on their biological activity (such as anti-cancer and anti-cholesterol activity) has led to the emergence of saponins as commercially significant compounds with expanding applications in food, cosmetics, and pharmaceutical sectors (Güclü-Ustündag and Mazza, 2007). In the field of cosmetics, many different products are made up from corn silk including cream, powder, liquid, capsules, gel, tincture or tea. For instance, to make skin look and feel healthy, skin brightening powder of cornsilk used, this powder contains the unique bio-active complex formulated with vitamins and botanicals, excellent as a highlighter, brightens and minimize the appearance of pores.

Medicinal importance of corn silk in health benefits

Corn silk is used as a medicine for centuries and is categorized as medicinal herb by practitioners of traditional medicine in many countries. It has long been used for treatment of several health problems such as kidney stones, nephritis, blood pressure, diabetics, cystitis, edema, gout, urinary infection etc in several countries. In Dominican Republic it is used to treat fibroids and to reduce cramps when combined with other plants (Ososki *et al.,* 2002). In Jordan, cornsilk is prescribed by some herbalists for treating cold and constipation as well as moderately used to treat kidney stones, oedema and obesity (Abu-Irmaileh and Afifi, 2003). According to an ethnobotanical survey in certain parts of Iranian provinces, corn silk is used to treat infections of urinary system (Mosaddegh *et al.,* 2012). Corn silk is very well known as an important traditional Chinese medicine in treating several illnesses related to kidney. It has been used to treat oedema, cystitis, gout, prostatitis and as antimicrobial agent (Velazquez *et al.,* 2005). Cornsilk has also been used to treat rheumatism and rheumatoid arthritis ailments (Maksimovic and Kovacevic, 2003). India has large diversity of plant resources that are very useful in the early middle ages to treat various types of ailment (Middha *et al.,* 2012). Many researchers demonstrated its effectiveness and suggested for treatment of different diseases and metabolic disorders as follows.

Diuretic activity and in treatment of kidney diseases

The potential of corn silk as a diuretic agent is first reported by Caceres *et al.* (1987). It is observed that a combination of aqueous extract of corn silk with *T. terrestris* resulted in similar diuresis effect as in *T. terrestris* aqueous extract alone (Al-Ali *et al.,* 2003). Pinheiro et al (2011) conducted in-vivo experiment and demonstrated the diuretic effect of corn silk. Effectiveness of cornsilk as a cure for kidney-related problems in traditional medicine has been shown by several scientific findings which support the use of corn silk as a diuretic remedy. Corn silk treatment 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). Sukandar *et al.* (2013) reported that corn silk and binahong leaves could improve kidney function in rat model of kidney failure. Combination of the half dose of each extract found significant improvement in functioning of the kidney. Corn silk has been used as a diuretic agent for treatment of kidney stone and urinary tract diseases (Aukkanita *et al.,* 2015). The CKD (Chronic Kidney Disease) is basically a common kidney disease, where patients will have gradual reduction of kidney function and over time damage kidneys. In addition to the effects on kidneys, this disease also increases the risk of having heart and blood vessels diseases. For its treatment, corn silk is usually prescribed in the form of corn silk tea. Corn silk tea has the function of increasing the urine output and removes the excess fluid out, which can help remove the toxins and wastes out, hence reducing creatinine level and can help relieve the swelling. In addition, High blood pressure, being the most prominent symptom, is also reduced with the help of corn silk tea (Vijitha and Saranya, 2017).

Anti-hyperglycaemic and anti-diabetes effect

Diabetic mellitus (DM) is a leading chronic metabolic disease worldwide that is associated with the abnormal functioning of the hormone insulin and often induces many serious complications and diabetic nephropathy. It is a complex metabolic disease characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Ibrahim *et al.,* 2016). As a folk medicine, Corn silk was used to treat DM due to its anti-diabetic potential. In 2009, Guo *et al.* reported that the corn silk extract causes reduction of blood glucose level in hyperglycaemic mice i.e. blood glucose level was decreased at higher doses of corn silk (4.0 g/kg body weight, BW). The level of serum insulin increased (9.8 ± 0.5 µU/mL) after being given 4.0 g/kg body weight of corn silk extract. After studied several parameters such as blood glucose, glycohaemoglobin (HbA1c), insulin secretion, pancreatic β-cells damage, hepatic glycogen and gluconeogenesis in the hyperglycaemic mice they concluded that the effect of cornsilk extract on glycaemic metabolism is via increasing insulin level and recovery of β-cells. Cornsilk polysaccharides exhibited anti-diabetic effect on streptozotocin (STZ)-induced diabetic rats (Zhao *et al.,* 2012). Corn silk inhibits α-amylase activity and slow down starch digestion rate and restrained the increase of post-meal blood sugar (Chen *et al.,* 2013). Chen and Guo (2018) reported that corn silk exhibit beneficial effect on glycemic metabolism through enhance insulin secretion whereby the augment of insulin level and recovery of â-cells possible through which corn silk control hyperglycemia. Pan *et al.* (2019) reported intake of corn silk polysaccharide increase serum insulin secretion and recover glucose intolerance in type 2 diabetics. Wang and Zhao (2019) suggested corn silk traditional use in the effective management of diabetic mellitus (DM) and diabetic nephropathy (DN). Thus, corn silk can be a potential bioactive agent for the effective management and treatment of diabetes mellitus.

Antihyperlipidemic, anti-obesity and antihypertensive effect

Obesity has become a major public health problem now a day which is associated with health conditions such as diabetes, cardiovascular disease, hypertension, cancer, reduced life expectancy, and poor cognition and motor control (Bray, 2004; Wang *et al.,* 2016). High-fat diets and frequent feeding of it contribute to elevating the triglycerides (TG) levels all day long, exposing the large quantities of atherogenic TG-rich lipoproteins that can penetrate and reside in the sub-endothelial space, contributing to foam cell formation and promoting lipid accumulation in the vessel wall which promotes endothelial cell (EC) activation and atherosclerosis (Yin *et al.,* 2015), one of the factors that triggered hypertension, cardiovascular disease, and stroke. Atherosclerotic cardiovascular disease (ASCVD) is the leading cause of death and it has been confirmed that increased low-density lipoprotein cholesterol (LDL-C) is an independent risk factor for atherosclerosis. Recently, evidence has shown that hypertriglyceridemia is associated with incremental ASCVD risk (Peng *et al.,* 2017). Yan *et al.* (2011) reported that flavonoids from cornsilk exhibit antihyperlipidemic effects and protect against atherosclerosis. High maysin corn silk extract inhibits adipocyte differentiation through inhibition of C/EBP-â and PPAR-ã AMPK expression in adipose tissue, inhibits expression of CD-36, AP-2, and LPL related to fat accumulation in adipose tissue, inhibits expression of ACC-1, GPAT-1, G6PDH, FAS, SCD-1, SREBP-1c, and PDK-4 related to fat synthesis, and increases expression of AMPK, CPT-1, and HSL related to lipolysis and fatty acid oxidation to reduce body fat, consequently reducing body weight in experimental animals (Lee *et al.* 2016). The Low-density lipoprotein (LDL) or the “bad” cholesterol, can gradually build up in the arteries (the blood vessels that carry blood throughout the body) and, over time, cause heart diseases and stroke. On the other hand, high levels of HDL (High-density lipoprotein), or “good” cholesterol, protect the heart by helping to remove the build-up of LDL from the arteries. The combination of high levels of triglycerides with low HDL and/or high LDL cholesterol levels can increase the risk of heart problems, such as heart attacks. Wu *et al.* (2017) reported that the flavonoid from corn silk extract reduces the serum total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-c) levels without any effect on High-density lipoprotein cholesterol (HDL-c) level. Cornsilk has been consumed regularly as a decoction in order to treat high blood pressure (Ong and Nordiana, 1999). George and Idu (2015) reported that corn silk aqueous extract exhibits an antihypertensive effect by lowering of blood pressure.

Anti-oxidative and anticancer effect

Corn silk has been used traditionally as a medicine for its antioxidant properties due to the presence of flavonoids, alkaloids, phenols, steroids, glycosides, and tannins in it. According to an experimental study, photochemical constituents, free radical scavenging activity and total antioxidant activity of various extracts of corn silk were carried out to test its anti-oxidant activity. Corn silk contains polyphenols that are responsible for free radical scavenging activities. The polyphenols content of corn silk varies from 6.70 to 101.99 mg GAE/g extract, depending on the solvent used and cornsilk extracts have shown strong antioxidant activities thus highly recommended to be implemented in the pharmaceutical and health related industries to treat oxidative stress related disease (Nurhanan and Wan Rosli, 2013). The antioxidant activities of all cornsilk extracts were determined via β-carotene bleaching method, 2,2-diphenyl-2-picrylhydrazyl (DPPH.) radical scavenging, superoxide anion (O_2^-) radical scavenging and ferric reducing power activity (FRAP). The highest polyphenol content was exhibited by the methanol extract (101.99 mg GAE/g) compared to that of ethanol (93.43 mg GAE/g), water (35.34 mg GAE/g) and ethyl acetate extract (6.70 mg GAE/g). The flavanoid content of cornsilk extracts was in the range of 0.66 to 9.26 mg catechin equivalent/g extract showing the highest content found in the methanol extract. In the antioxidant assays, the methanol extract exhibited the strongest free radical scavenging and reducing activity as compared to the other extracts. In the β-carotene assay, the methanol (66.05%) extract, showed highest bleaching activity compared to the ethanol (52.92%), water (38.65%) and ethyl acetate (26.33%) extract. In FRAP assay, the ferric reducing activity of methanol extract reached 56.41% at 1600 µg/ml while ethanol (51.16%), water (35.01%) and ethyl acetate extract (27.21%) exhibited lower reducing activity. methanol, water and ethyl acetate extracts of corn silk show a concentration-dependant manner based on DPPH, FRAP, XOD (xanthine oxidase) system and ABTS [2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonate)] free radical scavenging capacity. Inhibition of free radicals increases when a higher concentration of extract is applied. The free radical scavenging capacities of corn silk obtained from DPPH, FRAP, XOD, and ABTS assays could be attributed to the phenolics and flavonoids present in cornsilk powder. The flavonoid maysin from corn silk extract contains luteolin, a biologically active substance known to have antioxidant and anticancer activities (Lee *et al.,* 1998). The antioxidative activity of flavones in corn silk is associated with the prevention of cancer and coronary heart disease which is also promising (Birt *et al.,* 2001). Antioxidant activity from matured corn silk is higher than from the immature corn silk (Maksimovic and Kovaèevic, 2003). The upper parts of corn silk showed higher antioxidant activity than from the lower parts of corn silk (Alam, 2011). Several studies on maysin of corn silk have demonstrated antioxidative, antiallergy, and anticancer effects (Bai *et al.,* 2010; Hu and Deng, 2011, Lee *et al.,* 2016). Many researchers reported the anti-oxidant properties and effects of corn silk in their in-vitro studies (Maksimovic, *et al.* 2005; Liu *et al.* 2011; El-Ghorab, 2007; Ebrahimzadeh 2008; Kan 2011). Corn silk polysaccharide treatment was shown to enhance antitumor activity through increased immune capability and anti-inflammatory effects (Yang *et al.,* 2014; Wang *et al.,* 2012). Guo *et al.* (2016) investigated the anticancer activity of corn silk extract in human colon cancer cells and human gastric cancer cells and reported that corn silk extract inhibited the proliferation of cancer cells and increased the level of apoptosis in a concentration dependent manner.

Neuroprotective effects

The *in-vitro* data suggesting that herbal medicines like corn silk inhibits cholinesterase, resulting in neuroprotective effects of Alzheimer's disease, quoted by Natural Medicine Database. Alzheimer's disease might be prevented by inhibition of acetylcholinesterase (AChE) and butrylcholinesterase (BChE) as both of these degrade the neurotransmitter acetylcholine through hydrolysis. The neuroprotective effects of corn silk ethyl acetate and ethanol extract from four corn varieties (var. *intendata*, *indurata*, *everta* and *saccharata*) was investigated by measuring AChE and BChE inhibition (Bump and Brown, 1990). Among these, the ethyl acetate extract of var. *intendata* (200 µg/mL) had the highest AChE inhibition (96.69%), while at the same concentration ethyl acetate extract of var. *everta* exhibited the highest BChE inhibition (41.46%). High inhibition of AChE by ethyl acetate extract of corn silk showed that the extracts of corn silks have the potential to be used in neuroprotective applications. Maysin isolated from corn silk exhibits neuroprotective

effect via the antioxidative and anti-apoptotic mechanism (Kan *et al.,* 2011; Lee *et al.,* 2014).

Anti-depressant effect

In recent years, considerable attention has been directed towards the identification of plants with antioxidant and anti depressant ability that may be used in Human diet therapy. Ebrahimzadeh *et al*. (2009) studied the antidepressant activity of corn silk and reported corn silk has good anti-depressant potential. He also reported that the extract also had high levels of phenol and flavonoids and was so safe at least up to 4000 mg/kg.

Anti-inflammatory effect

Inflammation is part of the complex biological response of the vascular tissue system due to harmful stimuli, like infection by pathogens, damaged cells, or irritants. The classical signs of acute inflammation are pain, redness, swelling, and functions loss. Generally, two types of medicine are used to treat inflammation effects, steroidal and non-steroidal anti-inflammatory drugs but they have lots of side effects as well as many adverse effects on health so herbal medicines are now emphasized to use in the treatment of such diseases, because herbal medicines have little or no side effects. Corn silk is very well known for its anti-inflammatory properties. Traditional medicine followers are of the view that it can be used in reducing the pain caused by inflammatory ailments like gout and arthritis. Ethanol extract of corn silk inhibits the expression of ICAM-1 and adhesiveness of endothelial cells and causes anti-inflammatory effects (Stoecklin *et al.,* 2003). Kim *et al.* (2005) reported that corn silk stimulated COX-2 and secretion of PGE2. Anti-inflammation effects of corn silk were also observed by Wang *et al.* (2011) when carragenin-induced pleurisy rats were administered corn silk orally with corn silk for 6 hours. Pretreatment with corn silk extract also inhibited TNF-Î±, IL-1Î², VEGF-Î±, and IL-17A and blocked inflammation-related events (ICAM-1 and iNOS) by activation of NF-ÎºB. Supplementation with corn silk may be a promising treatment for inflammatory diseases that involve oxidative stress (Wang *et al.,* 2012). Corn silk polysaccharide Enhances antitumor activity through increased immune capability and anti-inflammatory effects (Yang, 2014).

Anti-microbial effect

Aqueous extract of corn silk possesses antimicrobial effects against *S. aureus, B. subtilis* and *Candida albicans* (Xing *et al.,* 2012). Petroleum ether (PECS) and methanol (MECS) extract and flavonoids were active against most of the gram-positive and gram-negative bacteria tested (Nessa *et al.,* 2012). Surjee and Zwain, (2015) reported that the ethanol and aqueous extracts of corn silk have inhibitory effects against bacteria. Corn silk can also be taken as a tea to treat the symptoms of UTI. Corn silk is best used in combination with other stronger antiseptic herbs to treat bladder infections and it will provide effective symptom relief from burning and pain associated with UTI (Vijitha and Saranya, 2017).

Present and future prospective

The interest in using corn silk in herbal medicines, food, and cosmetics has been increasing in the last few years. However, it is very important to carry out proper research on toxicity and determine the safety level before any use of it as food or in any herbal products. A recent study using male and female Wistar rats confirmed that corn silk is non-toxic in nature (Wang *et al.,* 2011). There were no histopathological and adverse effects observed at a corn silk concentration of 8.0% (w/w) consumed for 90 days. This content corresponds to a mean daily corn silk intake of approximately 9.354 and 10.308 g/day/kg body wt. for males and females, respectively. As such, the intake of corn silk has no adverse effects and this supports the safety of corn silk for human consumption. Researchers reported that acute and sub-acute toxicity studies 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). Because human research on corn silk is limited, official dosage recommendations haven't been established. A variety of factors could influence your body's reaction to this supplement, including age, health status, and medical history. Most available research suggests that corn silk is nontoxic and those daily doses as high as 4.5 grams per pound of body weight (10 grams per kg) are likely safe for most people (Hasanudin *et al.,* 2012). The therapeutic and health benefits exerted by corn silk may be linked

with the presence of various phytochemicals such as sterols, polyphenols, flavonoids, and anthocyanins as well as minerals and other essential nutrients. These substances are able to scavenge free radicals and have shown some significant *in vitro* and *in vivo* antioxidative activities thus this corn silk is also being utilized as a hypoglycemic agent, diuretic agent, antioxidant, and other therapeutic functionalities. No doubt, the benefits of corn silk in improving pharma-nutritional functionalities can be very useful for future studies. Recently, a novel coronavirus, COVID-19 has been creating havoc with huge numbers of casualties the world over. Till now, although hundreds of years have passed, research in the entire world could not be able to eradicate the viral deaths and the pandemic issues in right earnest hence, children's health and safety are at risk (Das *et al.* 2021). Thus there are huge scopes for further research to study the effect of corn silk on viral pathogens of humans for all age groups as well as its role in immunity development against COVID-19 and other pathogenic viruses.

The processed dried corn silk has been successfully incorporated into food products to enhance nutritional values and physiological functionalities. Incorporation of corn silk powder results in increasing protein, cooking yield, moisture, and fat retention (Wan Rosli *et al.*, 2011). Food-derived bioactive peptides received growing attention by the researchers over the last two decades. These multifunctional peptides are used for the prevention of cardiovascular disease. Antioxidant peptides are recognized as potent, natural alternatives to synthetic antioxidants for application as food additives. Such peptides are also potential for the future development of functional food ingredients and therapeutic agents (Lammi *et al.* 2019). Recently, consumer demand for healthy snacks has increased. Crackers are popular healthy snacks with a high potential to enhance nutritional value by incorporating naturally available ingredients. Corn silk incorporated crackers are rich in calories, protein, fibre, and minerals. The pulverized dried corn silk can effectively use to prepare value-added food products (Priyadharshini, K. and Parameshwari, 2020). The value added by incorporating corn silk powder will enhance the nutritional quality. Hence, corn silk powder can be exploit as a mean of value addition in different novel products. Corn silk is considered as a good source of nutritional composition and potential antioxidant activity thus incorporation of corn silk powder resulted in increased protein, fibre, vitamin C, calcium, and magnesium in the crackers. Crackers with 10% corn silk added were highly acceptable by the consumers. This novel corn silk for incorporation in crackers could permit a reduction of formulation cost without affecting sensory attributes of the developed product with which the consumer is familiarized. The addition of corn silk powder in butter biscuits improves some essential nutrients and healthy functional properties. Considerable higher polyphenol content (60.4-86.8%) and antioxidative improvement are obtained by the incorporation of corn silk powder in butter biscuits. The corn silk powder-based biscuits have higher free radical scavenging capacity (24.45-62.73%) and ferric-reducing capacity (16.94-342 μmolTE/g) with higher levels of gallic acid and ferulic acid compared with all-wheat-based biscuits (Nurhanan and Wan Rosli, 2016). The addition of corn silk powder in traditional Indian snack laddoo of different blends like raw papaya, rice flour, and sesame seeds was found to be organoleptically acceptable. For laddoo of all three blends, corn silk powder can be added up to a level of 10% for value addition to increase the fiber, protein, and mainly the mineral content of the product as well as imparting curative effects to the products (Singh and Raghuvanshi, 2021). In addition to these, the processed corn silk shows some beneficial effects when it is applied to few other food items such as bread and patties. Incorporation of corn silk powder results in increased protein, total dietary fibre and firmness but decreases sensory acceptability of yeast bread. Addition of 2% corn silk powder to yeast bread also slightly increases protein, ash and TDF content, meanwhile their textural properties and sensory acceptability are unchanged compared to control yeast bread. On the other hand, yeast bread with 6% corn silk-added has the highest content of protein; ash and TDF content but adversely affects the textural and sensory acceptability (Ng and Wan Rosli, 2013). The utilization of corn silk, on one hand will promote value addition of the products and on the other hand, will provide low-cost nutritious alternatives, especially in poor developing countries for combating malnutrition among children and vulnerable sections of the society. Corn Silk is also having traditional use in cosmetic preparations to soften the skin tissues (Emollient) and overcome skin rashes. The application of corn silk extracts on faces with hyper pigmentation significantly reduced the skin pigmentation without abnormal reactions. It has good prospects for

suppressing the skin pigmentation (Choi *et al.*, 2014). Thus the corn silk is a potential source of an extra income to the farmers and there is a vast scope for research and development of different value-added products by utilizing this corn silk and its extracts. This will lead to the valorization of agricultural residue via waste utilization which increases farmer income as well as reduce environmental pollution due to agricultural wastes, which will lead to the valorization of agricultural residue via waste utilization which increases farmer income as well as reduce environmental pollution due to agricultural wastes.

Conclusion

Corn silk could be potential health promoting agent in humans. Several studies have demonstrated the therapeutic potential of corn silk extract against several diseases including diabetes, hyperlipidemia, cancer, obesity, cardiovascular diseases, kidney disease, and microbial infections. In addition to that, the processed corn silk shows some beneficial effects when it is applied in some food items such as biscuit, bread, laddoo, cookies, crackers and patties. These products being inexpensive and highly nutritious as well as rich in fiber they can surely be a promising solution to improve defecation pattern by recommending these products to be supplemented through various dietary intervention program. However, further studies are needed to standardize the effective doses for different health purposes for different age groups and to investigate in detail the molecular mechanisms by which corn silk extract exhibits health-promoting effects. Thus, there is a great need to strengthen research, testing, and product development activities for proper, effective, and safe utilization of corn silk in development of nutritious food so that in near future, it can be utilized effectively to prevent malnutrition and health problems.

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