Chapter 4

Phytochemical Composition: Antioxidant Potential and Biological Activities of Corn

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.79648

Abstract

Corn seeds are used as a nutritional source for humans, and the stem and leaves are utilized as fodder for cattle throughout the world. Corn silk and corn cob are usually discarded as waste. This chapter highlights the nutritional as well as medicinal importance of various parts of corn plant. All parts of corn plant are good source of a variety of bioactive phytochemical compounds which possess antioxidant potential. The principal phytochemicals present in corn seed and corn silk include polyphenols, phenolic acids, flavonoids, anthocyanins, glycosides, carotenoids, and polysaccharides of biological importance, reducing compounds and some water-soluble vitamins. The presence of these phytochemicals makes corn a medicinal plant which shows various biological activities particularly the antioxidant, antimicrobial, antidiabetic, anti-obesity, antiproliferative, hepatoprotective, cardioprotective, and renal-protective activities. On the account of its high antioxidant potential, all parts of corn plant can be used for the management of oxidative stress and the treatment of various diseases.

Keywords: corn, *Zea mays*, maize, phytochemical composition, antioxidant potential, biological activities

1. Introduction

Corn (*Zea mays* L.), which belongs to the family Poaceae (Gramineae), is the principle cereal crop around the world following wheat and rice. Its annual production reaches almost 780 million metric tons, of which the larger producers are the USA, China, Brazil, and India. It is an annual herbaceous plant having 2–20 feet high stalk. The genus *Zea* comprises five species

Z. diploperennis, Z. luxurians, Z. nicaraguensis, Z. perennis, and Z. mays. Zea mays is the only cultivated species, while others are wild grasses [1–4].

The corn plant is classified as:

Kingdom	Plantae
Family	Poaceae
Subfamily	Panicoideae
Genus	*Zea*
Species	*mays*
Synonyms	Maize, corn, mealie

Various parts of corn such as grains, leaves, corn silk, stalk, and inflorescence are commonly used as food for humans, feedstuff for animals, fuel for small industries, and potential ingredient of homemade remedies [3, 5]. Corn seeds are served as food in Asian countries including China, Korea, Taiwan, Vietnam, Laos, Myanmar, Thailand, India, and Pakistan [6]. The unripe seeds of sweet corn are eaten raw or cooked, while the mature seeds are dried and ground to make flour that is used in various food preparations. The major products of wet and dry milling of corn seeds are used to make breakfast cereals, snacks, and tortillas, while the coproducts are used as animal feed. The maize flour has been found to enhance the nutritional and functional quality of food materials when used in the form of blend with other cereal flours [7, 8]. Corn kernel is also used to obtain ethanol as a fuel [9]. Oil obtained from seeds is edible and is used in the preparation of various food products. A semidrying oil obtained from seeds has many industrial uses like manufacturing of linoleum, paints, varnishes, and soaps.

The edible part of corn is covered by long, silky, and colored (yellowish to reddish) hairlike structures known as corn silk. Corn silk, due to its high medicinal value, has been traditionally used as herbal remedies for the treatment of various diseases [6]. It has been reported to be used in the treatment of hypercholesterolemia, urinary infections, and associated diseases [10]. Corn silk is also used as an important ingredient in development of various drugs [11]. It has been found to be nontoxic and is safe for human consumption [12, 13]. In Asia, it is used in tea as a healthy and medical drink [14]. Corn silk powder can also be used as food additive and flavoring agent as it does not change the taste; rather, it enhances the content and physical characteristics of meals like beef patties [15, 16]. Pith of the stem of corn plant is used to make corn syrup [17], the spathes are used in making papers, straw hats, and baskets, and dried cobs are used as fuel [3].

2. Nutritional composition

Corn, due to its high nutritional quality, is a permanent global crop used to fulfill the nutritional requirements of humans and cattle [3]. Corn is rich in nutritional compounds such as carbohydrates, proteins, vitamins, and minerals including calcium, magnesium, potassium, and sodium salts [3]. Corn seeds contain sugars (16.39–21.20 g/100 g dw), protein (11.46–12.70 g/100 g dw), and crude oil (5.73–6.21 g/100 g dw) [18]. Corn silk contains moisture (9.65–10.4%), protein (9.42–17.6%), fat (0.29–4.74%), ash (1.2–3.91%), dietary fiber (7.34%), and carbohydrates (65.5–74.3%), and good composition of vitamins and minerals as sodium, potassium (28, 1360 mg/100 g dw, respectively), calcium, magnesium, iron, zinc, manganese, and copper (0.1869, 0.1939, 0.005, 0.0165, 0.0109, and 0.0073 mg/g fw, respectively) [3, 19, 20]. The processed corn silk contains significant amounts of crude fiber (13%), crude protein (13%), and carbohydrates (69%). Being low in crude fat content, corn silk can be preferably used in the preparation of fat-free food formulations [21].

3. Phytochemical composition

Phytochemicals are the non-nutritional bioactive compounds found in various parts of plants. In plants these compounds perform vital functions particularly protection from predators and harsh environmental conditions. These compounds are also important in pharmaceutical and medicinal field due to their antioxidant, antimicrobial, and other biological properties. Flavonoids are the bioactive phytochemical compounds which make the plant resistant to the attack of microbes and insects and also protect the animals against various diseases [22–24]. Flavonoids possess strong antioxidant activity and free radical-scavenging capacity and inhibit protein glycation [23, 25, 26]. The anthocyanins have been found to protect against ischemic reperfusion injury in rats [27]. These have been also found to show antioxidant and antiradical activities which are further associated with certain health-promoting activities such as anticancer, anti-inflammatory, anti-obesity, antidiabetic, cardioprotective, and hepatoprotective activities [28–30]. Tannins are polyphenolic compounds which show several biological activities such as anti-inflammatory, antioxidant, free radical-scavenging, and antimutagenic activities [31, 32].

Various parts of corn plant such as silk, seed, stem, leaves, and roots are good sources of bioactive phytochemical compounds such as phenolic acids, flavonoids, steroids, alkaloids, carotenoids, tannins, saponins, anthocyanins, and other phenolic compounds [6, 28, 33, 34]. Corn seeds contain polyphenols, phenolic acids, flavonoids, anthocyanins, carotenoids, vitamins, sugars, polysaccharides, and other phytochemicals of medicinal importance [35, 36]. Corn silk contains a number of bioactive phytochemical compounds including phenols, polyphenols, phenolic acids, flavonoids, flavone glycosides, anthocyanins, carotenoids, terpenoids, alkaloids, steroids, luteins, tannins, saponins, volatile oils, vitamins, some sugars, and polysaccharides (**Table 1**) [6, 11, 22]. The corn silk flavonoids have been also reported to reduce the oxidative stress and show anti-fatigue activity in mice [37, 38]. The content of the major phytochemical compounds found in various parts of corn are summarized in **Table 2**.

Corn part	Class of phytochemicals	Phytochemical components	Reference
Corn silk	Polyphenols	Tannins, saponins, flavonoids, alkaloids, steroids, cardiac glycosides, allantoins, anthocyanins, hesperidin, and resins	[19]
	Phenolic acids	Para-aminobenzoic acid (PABA), vanillic acid, p-coumaric acid, chlorogenic acid, protocatechuic acid, caffeic acid, ferulic acid, maizenic acid, hydroxycinnamic acid ester, and 3-O-caffeoylquinic acid	[20]
	Flavonoids	Catechin, protocatechin, quercetin, rutin, flavone, 3-hydroxyl, 4-hydroxy, 5-hydroxy, and 7-hydroxy flavones and isoflavones. 2-O-α-L-rhamnosyl-6-C-3-deoxyglucosyle-3-methoxy luteolin and 6,4-dihydroxy-3-methoxyflavone-7-O-glucoside.	[11, 36, 73–76] [20, 34, 77]
		Isoorientin-2-2-*O*-α-L-rhamnoside, cardiac glycosides	
		Luteolins: 2″-O-α-L-rhamnosyl-6-C-quinovosylluteolin, 2″-O-α-L-rhamnosyl-6-C-fucosylluteolin, and 2″-O-α-L-rhamnosyl-6-C-fucosyl-3′-methoxyluteolin, 2″-O-α-L-rhamnosyl-6-C-3″-deoxyglucosyl-3′ methoxyluteolin, 2″-O-α-L-rhamnosyl-6-C-(6-deoxyxylo-hexos-4-ulosyl)-luteolin, 2″-O-α -L-rhamnosyl-6-C-(6-deoxy-xylo-hexos-4-ulosyl)-luteolin-3′-methylether, kaempferol	
		Maysins: Rhamnosyl-6-C-(4-ketofucosyl)-5, 7, 3′4′-tetrahydroxyflavone, ax-5′-methane-3′-methoxymaysin, ax-4″-OH-3′-methoxymaysin, 6,4′-dihydroxy-3′-methoxyflavone-7-O-glucosides, 7,4′-dihydroxy-3′-methoxyflavone-2″-O-α-L-rhamnosyl-6-C-fucoside	
	Carotenoids	β-Carotene, zeaxanthin	
	Sterols	Phytosterols like stigmasterol, beta-sitosterol	
	Tannins	Gallotannins, phlobatannins	
	Volatile compounds	Menthol, carvacrol, thymol, eugenol, neo-iso-3-thujanol, *cis*-sabinene hydrate, 6,11-oxidoacor-4-ene, citronellol, *trans*-pinocamphone, *cis*-sabinene hydrate, *cis*-R-terpineol, and neo-iso-3-thujanol	[78]
	Vitamins	Vitamin C, vitamin K, vitamin E	[79]
	Sugars	Dextrose, xylose	
	Miscellaneous compounds	Polysaccharides (galactan), geraniol, limonene, terpenoids, α-terpineol, citronellol,	[6, 23, 25, 34–36, 49, 55, 70, 74, 75, 78, 80]
		trans-pinocamphone, formononetin, apigenin, pelargonidin, anthraquinones, hordenine,	
		xanthoproteins,	
Corn seeds	Polyphenols	Tannins, saponins, rutin, allantoins, quercetin, isoquercetin, morin, naringenin, kaempferol	
	Phenolic acids	Gallic acid, chlorogenic acid, syringic acid, hydroxycinnamic acid derivatives, ferulic acid, 7-hydroxy-2-indolinone-3-acetic acid, caffeic acid	[35]
	Flavonoids	Anthocyanins, quercetin, and catechin	[81]
	Carotenoids	Carotenes including lutein, cyclosadol, β-cryptoxanthin, zeaxanthin, α- and β-carotene, α and β-cryptoxanthin	[82]
	Anthocyanins	Cyanogenic glycosides including pelargonidin-3-glucoside, cyanidin-3-glucoside, and peonidin-3-glucoside	[36]
	Vitamins	Vitamin E (tocopherols), vitamin B (biotin, riboflavin, pantothenic acid, folic acid, niacin, pyridoxine, thiamine), vitamin C	[83]
	Miscellaneous compounds	Polysaccharide, sugars, proteins, inositols, resins, hexaphosphoric and maizenic acid, esters of indole-3-acetic acid, d-glucose hydroxyl-2-indolinone-3-acetic acid, N-coumaryltryptamine, N-feruloyltryptamine, 6-methoxybenzoazoline, oxalic acids, essential fatty acids, and choline	[28, 30, 35, 78, 82]

Corn part	Class of phytochemicals	Phytochemical components	Reference
Corn stem	Phenolic compounds	Methyl (E)-p-cumarate, methyl (Z)-p-cumarate, methyl ferulate, and 1,3-O-diferuloyl glycerol	[84]
	Lignan	Tetrahydro-4,6-bis(4-hydroxy-3-methoxyphenyl)-1H,3H-furo[3,4-c]furan-1-one	[81]
	Flavonoids	Tricin, salcolin A, and salcolin B	[81]
	Anthocyanins	Cyanidin-3-glucoside, pelargonidin-3-glucoside, and peonidin-3-glucoside	[27, 29, 67]
Corn root and shoot	Polyphenols, flavonoids, and others	Flavonoids, terpenoids, alkaloids, tannins, phlobatannins, saponins	[85]

Table 1. Bioactive phytochemical components in various parts of corn.

Corn part	Extracting solvent	TPC	TFC	TAC	TCC	References
Corn silk	Water	1.5 mg GAE/g extract	2–7 μg/ml extract			[86]
		35.34–64.22 mg GAE/g extract	2.31–7.55 mg CE/g extract			[79, 87]
		42.71 μg TAE/g extract				[88]
		256.36–272 mg GAE/100 g dw	4.1–38.01 mg CE/g dw			[87, 89],
	Hot water	68.61 mg GAE/g	72.74 mg QE/g	0.02 mg CGE/g		[21]
	Methanol	101.99–175.8 mg GAE/g dw	0.66–9.26 mg CE/g dw			[87, 90]
		40.38 μg TAE/g extract		0.017–0.023 g CGE/100 g dw.		[18, 88]
		272.81 mg GAE/100 g dw				[89]
	Methanol acidified with 1% citric acid	69.01–85.49 mg GAE/100 g of fw		78.90–408.54 mg CGE/100 g fw		[91]
	Ethanol	164.1 μg GAE/g dw	69.4 μg RE/g dw			[34]
		1756 mg chlorogenic acid/100 g dw		1779 mg CGE/100 g dw.		[92]
		86.26–143.58 mg GAE/g extract	14.66–26.63 mg CAE/g extract			[79, 93]
		80.8–117.1 μg GAE/g dw	30.1–88.8 μg RE/g dw	0.4–72.9 μg CGE/g dw		[57, 41]
		93.43 mg GAE/g dw	65.58 mg RE/g dw			[87, 90],
		34029.37 ± 1926.61 mg /kg dw	211.05 ± 3.73 mg/kg dw		11.3 mg/kg dw	[94]
	Aqueous acetone	2093–4447 81 mg GAE/100 g dw	1840–3644 mg CE/100 g dw	1.49 mg CGE/100 g dw		[20],
	Ethyl acetate	6.70 mg GAE/g extract	8.40 mg CE/g extract			[90]

Corn part	Extracting solvent	TPC	TFC	TAC	TCC	References
Corn kernel	Methanol	115.4–175.5 mg GAE/100 g dw			6.7 μg/g fw, 9.7 μg/g dw	[95]
	Methanol acidified with citric acid	17.67–23.97 and 2.1 mg GAE/g fw, 2.8 mg GAE/g dw		16.53–45.84 mg CGE/100 g fw, 0.3 mg CGE/g fw, 0.4 mg CGE/g dw		[61, 91]
	Methanol acidified with HCl		178–515 mg NE /100 g dw	0–90 mg CGE /100 g dw		[95]
	Ethanol	223–467 mg GAE /100 g dw			16–564 μg/100 g dw	[82]
	Ethanol acidified with citric acid	287.3 ± 0.03 mg GAE/100 g fw		70.50 mg CGE /100 g		[41]
		20.06–24.97 mg GAE/100 g fw		25.8–133.26 mg CGE/100 g fw		[61, 91]
		353 ± 53 mg GAE/100 g dw	270 ± 62 mg NE /100 g of dw	30 ± 26 mg CGE /100 g dw	135 ± 119 μg/100 g dw	[95]
	Aqueous alcohol	215.8–3400 53 mg GAE/100 g dw		1.54–850.9 mg CGE/100 g dw		[96]
Corn cob	Methanol			129–1166 mg/100 g dw		[67]
	Methanol acidified with citric acid	15.43–64.02 mg GAE/100 g fw		17.87–115.97 mg CGE/100 g fw		[91]
	Various polarity solvents	79.61–92.64 mg GAE/g extract, 0.86 g GAE/100 g	14.41 mg CAE/g extract, 1.56 g QE/100 g, 0.46 g QE/100 g		0.85–1.18 g BCE/100 g	[93, 97]
Corn leaves	Various polarity solvents	4.94–1.75 g GAE/100 g	17.68 g QE/100 g		3.73–44.91 g BCE/100 g	[97]
Corn shoot	Water	69 μg GAE/g extract				[85]
	Ethanol	31.32 μg GAE/g extract				[85]
Corn root	Water	9.98 μg GAE/g extract				[85]
Corn husk	Various polarity solvents	1.62–14.77 g GAE/100 g	1.48–2.05 g QE/100 g		0.45–3.63 g BCE/100 g	[97]

GAE, gallic acid equivalent; RE, rutin equivalent; TFC, total flavonoid content; TPC, total phenolic content; TAC, total anthocyanin content; CGE, cyanidin-3-glucoside equivalents; fw, fresh weight; CE, catechin equivalent; TCC, total carotenoid contents; QE, quercetin equivalent; BCE, β-carotene equivalent; dw, dry weight; NE, naringin equivalent; TAE, tannic acid equivalent.

Table 2. Phytochemical composition of extracts from various parts of corn.

4. Antioxidant potential

The pharmaceutical and medicinal significance of medicinal plants is usually based on their antioxidant phytochemical composition. Antioxidants are the substances which have the ability to prevent the oxidation reactions in living and nonliving systems. They possess hydrogen-donating ability due to which they reduce other species and are themselves oxidized. These substances perform their action by reducing the reactive oxygen or nitrogen species or metals in their oxidized forms. These substances have the ability to terminate the free radical chain reactions occurring in the living system. Owing to their antiradical and reducing properties, the antioxidant phytochemicals play a key role in the preparation of pharmaceutical formulations against various diseases. The diversity in the phytochemical quality and high content of bioactive antioxidant phytochemicals make corn a valuable candidate for pharmaceutical application. Among various parts of corn, the corn silk is a rich source of antioxidant compounds and possesses strong antioxidant potential. The antioxidant properties of various parts of corn studied in terms of total antioxidant activity, ferric reducing, iron chelating, copper-reducing properties, and free radical-scavenging capacities are presented in **Tables 3–5**. The corn extracts have been also reported to improve the antioxidant status of various organs by affecting the activity of antioxidant enzymes [38].

Corn part	Extracting solvent	TAOA	β-CABC	References
Corn silk	Water	73–44.19%		[87]
	Methanol		66.05%	[87]
	Ethanol	5.61–9.98 mg $FeSO_4$/g dw	52.92%	[87]
	Ethyl acetate	2.15–2.735 mg GAE/g dw	38.65%, 26.33%	[87, 89]
Corn seed	Methanol acidified with citric acid	1827.5–2429.3 μmol TE/100 g dw, 61.15%, 3.1 μmol TE/g fw, 3.8 μmol TE/g dw, 17.9–32.19%		[61, 82, 91]
	Methanol acidified with HCl	18–100 μmol AAE/100 g		[95]
	Ethanol acidified with citric acid	22.95% TE		[41]
Corn cob	Methanol	0.3–10.2 μmol/g dw		[67]
	Methanol acidified with citric acid	31.10%		[91]
Corn husk	Methanol acidified with citric acid	11.85%		[91]

TAOA, total antioxidant activity; β-CABC, β-carotene-bleaching capacity; GAE, gallic acid equivalent; TE, Trolox equivalent; AAE, ascorbic acid equivalent; fw, fresh weight; dw, dry weight.

Table 3. Total antioxidant activity and β-carotene-bleaching capacity of extracts from various parts of corn.

Corn part	Extracting solvent	FRAP	*CRC*	References
Corn silk	Water	35.01%		[87]
	Methanol	56.41%		[87]
	Ethanol	51.16%, 38.90–65.46%		[87, 93]
	Ethyl acetate	27.21%		[87]
Corn kernel	Methanol	6.4–12.7 37 μM TE/g dw		[95]
	Methanol acidified with citric acid	0.09 μmol Fe(II) E/g fw 0.10 μmol Fe(II)/g dw 13.1–26.1 μM TE/g		[61, 82, 98]
	Methanol acidified with HCl	9 ± 2 mmol TE/100 g dw		[95]
Corn cob	Various polarity solvents	35.81–41.39%	EC_{50} (218.1–735.0 μg/ml)	[93, 97]
Corn leaves	Various polarity solvents		EC_{50} (152.3–248.8 μg/ml)	[97]
Corn husk	Various polarity solvents		EC_{50} (205.7–723.4 μg/ml)	[97]

FRAP, ferric-reducing antioxidant power; *CRC*, cupric-reducing capacity; EC_{50}, effective concentration required for 50% inhibition; TE, Trolox equivalent.

Table 4. Metal-reducing capacity of extracts from various parts of corn.

Corn part	Extracting solvent	DPPH	ABTS	References
	Water	63.5%		[89]
		IC_{50} (195.21 μg/ml)		[99]
	Methanol	81.7%		[89]
	Methanol	IC_{50} (0.10–0.18 mg/ml)		[18]
	Methanol	41–76%		[19]
	Methanol	IC_{50} (140.89 μg/ml)		[99]
		81.7–71.5%		[89]
Corn silk	Ethanol	84%, 68–75.6%		[78]
		68.4–75.6%		[57]
		IC_{50} (140.89 μg/ml)		[87]
	Ethanol	IC_{50} (143.55 μg/ml)		[99]
	Ethanol-water	92.6% with IC_{50} (0.56 mg/ml)		[6]
	Ethyl acetate	IC_{50} (411.69 μg/ml)		[99]
Corn seed	Methanol	IC_{50} (66.3–79.8 μg/ml) IC_{50} (52–177 mg/ml)	IC_{50} (219–799 μg/ml)	[40, 98]
	Methanol acidified with citric acid	13.15%, 28.7% fw, 34.2% dw, 10.48–13.46%		[61, 91]
	Methanol acidified with HCl		5–14 μM TE/g dw 11 ± 2 mmol TE/100 g dw	[95],
	Ethanol acidified with citric acid	49.2 μM ET/g		[41]

Corn part	Extracting solvent	DPPH	ABTS	References
Corn cob	Methanol	4–22 μmol/g dw		[67]
	Methanol acidified with citric acid	21.01%		[91]
	Various polarity solvents	IC_{50} (11.8–154.4 μg/ml)		[97]
Corn husk	Methanol acidified with citric acid	10.25%		[91]
	Various polarity solvents	IC_{50} (34.1–170.9 μg/ml)		[97]
Corn leaves	Various polarity solvents	IC_{50} (9–78 μg/ml)		[97]

DPPH, 2,2-diphenyl-1-picrylhydrazyl radical-scavenging ability; IC_{50}, inhibitory concentration required for 50% inhibition; ABTS, azino-bis-tetrazolium sulfate.

Table 5. Free radical-scavenging capacity of extracts from various parts of corn.

5. Biological activities

Epidemiological studies have demonstrated a relationship between the consumption of food with high quantities of phenolic compounds and a reduction in the risks of chronic and degenerative diseases, such as cancers and cardiovascular disease. Corn seed possesses antidiabetic, antioxidant, antiproliferative, and anti-cataractogenic activities [18, 39–41].

Corn part	Extracting solvent	Activity	Reference
Corn silk	Water	Diuretic and kaliuretic activity with reduced glomerular function, anti-hepatocarcinomic, antiadipogenic, antiobesitic, antihyperglycemic, antidiabetic, lipid lowering, hematinic, anti-inflammatory, and analgesic activity	[43, 55, 59, 99, 100]
	Hot water	Antioxidant activity and inhibition of IgE antibody formation in mice	[48, 101]
	Methanol	Antioxidant, antimicrobial, anti-hyperthyroidism, inhibition of lipid peroxidation, immunomodulatory activity by enhancing the innate immunity, lipid lowering, and cardioprotective activity	[19, 47, 49, 102, 103]
	Ethanol	Inhibition of tumor necrosis factor-α and adhesion of leukocytes to cell surface, activation of human peroxisome proliferator activator receptors, induction of antioxidant enzymes, and reduction of oxidative stress, antioxidant and free radical-scavenging, urease inhibitory, anti-hyperlipidemic, and diuretic activity	[34, 38, 44, 46, 50, 76, 104]
	Aqueous alcohol	Anti-fatigue, hepatoprotective, and renal protective activity in terms of inhibition of lipid peroxidation	[10, 37, 105–108]
	Aqueous acetone	Antioxidant activity	[20]
	Various polarity solvents	Antioxidant activity in terms of free radical-scavenging, metal-reducing and beta-carotene-bleaching capacities and antimicrobial activity	[24, 87, 109]
	Corn silk powder	Antioxidant and immunostimulatory activity in fish	[110]

Corn part	Extracting solvent	Activity	Reference
Corn seed	Methanol	Antioxidant activity in terms of free radical-scavenging and metal-reducing capacity	[18, 40]
	Aqueous alcohol	Antioxidant and anti-cataractogenic activity against diabetic cataract	[39]
Corn stem	Methanol	Anti-inflammatory, neuroprotective, hepatoprotective, and antioxidant	[81, 84]
Corn husk	Ethanol	Nephroprotective activity by dose-dependent increase antioxidant enzymes in diabetic rat	[111]

Table 6. Biological activities of extracts from various parts of corn.

Corn silk has been traditionally used for the treatment of several ailments due to various pharmacological activities exhibited by its extracts. It has been found to possess antioxidant, antidiabetic, antiproliferative, antimutagenic, anticoagulant, antifungal, antiadipogenic, anti-obesitic, antihypertensive, antihyperlipidemic, antilithiatic, antibiotic, antibacterial, antiseptic, anti-inflammatory, antidepressant, and anti-fatigue activities [6, 11, 34, 38, 42, 43]. It has been also reported to possess antihyperglycemic, antihyperlipidemic, diuretic, neuroprotective, hepatoprotective, and uricosuric activities [44, 45]. Corn silk has been investigated to activate the receptors for the binding of human peroxisome proliferator activators used in the treatment of diabetes [46]. Its methanolic extract has been found to be effective in thyroid dysfunction [47]. Corn silk extracts contain certain bioactive compounds which show immunomodulation activity [33, 48, 49]. Corn silk extracts have been also found to be effective in inhibition of tumor necrosis factor-α and adhesion of leukocytes to cell surface and induction of nitric oxide synthase and cyclooxygenase in macrophages [50–52]. The chemically modified corn silk polysaccharides have been reported to show antioxidant and amylase inhibitory activities [14]. Recently, the studies have shown that corn silk has no cytotoxic effect, but the excessive use of corn silk may be cardiotoxic particularly in patients with compromised cardiac health [4]. The biological activities of various extracts of different parts of corn are presented in **Table 6**.

6. Medicinal importance

Corn seed kernel is commonly used as nutritional purpose, but owing to its good phytochemical composition and biological properties, it has great medicinal value. The toxicological assessment of corn at various doses against various clinical parameters has proven it clinically nontoxic and can be used for nutritional and medicinal purposes [53]. Anthocyanins in purple waxy corn have been reported to be effective against diabetic cataract [39]. Corn silk is usually discarded as waste and not used for nutritional purpose. However, it has a great medicinal importance due to the presence of valuable bioactive phytochemical compounds. It has been traditionally used as an effective herbal remedy for the treatment of hyperglycemia, diabetes, obesity, hypercholesterolemia, hyperthyroidism, rheumatism, arthritis, gout, tumors, hepatitis, heart problems, jaundice, malaria, inflammation, asthma prostatitis, cystitis, nephritis, kidney stones, bed wetting, renal conditions, and other kidney-related diseases. Corn silk is also known to be urine laxative, antihypertensive, and immune enhancer. Corn silk tea has been used as diuretic for the treatment of urinal irritation. In combination with other herbs, corn silk has been found to be effective against mumps or inflammation of the bladder. It has been also reported to be useful in gonorrhea, acute and chronic cystitis, and bladder irritation due to uric acid and phosphate gravel [11, 14, 37, 38, 42–44, 46, 47, 51, 54–59]. Recently, corn silk polysaccharides have been suggested to be a good choice as functional food or medicine for the treatment of type 2 diabetes mellitus due to its hypoglycemic activity [60].

7. Factors affecting the phytochemical profile and antioxidant potential of corn

There are several factors which have been reported to affect the phytochemical quality and antioxidant potential of various parts of corn. The phytochemical composition and antioxidant profile of maize have been observed to be different in different varieties and at various stages of maturity [18, 61–63]. The phytochemical content of corn silk has been found to be enhanced by treatment with red algae [64]. The location, climatic, water stress, irrigation method, and plant density significantly affect the growth, metabolism, and physiological characteristics of corn plant [65–67]. The spraying of salicylic acid and collection period have been found to increase the growth rate and phytochemical content of corn silk [68]. The fermentation of corn samples has been found to result in an increase in carotenoid and ascorbic acid content with a slight decrease in antioxidant activity [69]. The germination conditions between light and dark periods have been also found to affect the morphological structures, biochemical and phytochemical composition, and antioxidant activity of corn sprouts [70]. The storage conditions, processing techniques, and cooking methods have been also found to affect the phytochemical content and free radical-scavenging activity of maize [21, 71]. Recently, studies in our laboratory have shown that high-dose gamma irradiation results in a decrease in antioxidant properties of corn flour [72].

8. Conclusion

All parts of corn plant are good sources of phytochemical compounds which possess antioxidant potential. Corn seed have a valuable role in human nutrition, while corn silk has a great medicinal importance due the presence of a variety of bioactive phytochemical compounds. The principal phytochemicals present in corn silk include polyphenols, phenolic acids, flavonoids, anthocyanins, glycosides, carotenoids, and some water-soluble vitamins. The presence of these phytochemicals makes corn a medicinal plant which shows various biological activities particularly the antioxidant activity. On the account of its high antioxidant potential, all parts of corn plant can be used for the management of oxidative stress and the treatment of various diseases.

Conflict of interest

I confirm that there are no conflicts of interest.

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