



(REVIEW ARTICLE)



## A review of phytochemicals isolated from corn silk and their medicinal applications

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### Abstract

Corn silk (*Stigma maydis*) is an important herb employed in traditional medicine in many parts of the world, such as Nigeria, China, Turkey, France, United States to mention a few. It has been used as diuretic, antilithiasic, uricosuric, antiseptic in the treatment of cystitis, gout, nephritis, tumor, hepatitis, edema, kidney stones, diabetic, inflammation reduction, prostate disorder/problems/prostatitis, urinary tract infections, bedwetting, obesity, malaria, heart problems, soothes and relaxes the lining of the bladder and urinary tubules, reduces irritation and increasing urine secretion, exerts anti-fatigue activity, exhibits anti-depressant activity and kaliuretic, excellent antioxidant capacity, demonstrates protective effects in radiation and nephrotoxicity, lowers high blood pressure (by reducing fluid retention in the body and also by eliminating toxins which could relieve symptoms of gout, edema and arthritis), promotes relaxation, cures hypercholesterolemia and urinary infections associated diseases, effective for weight loss amongst other. The potential use of corn silk is very much connected to its properties and mode of action of its bioactive phytoconstituents. Hence, this review covers the traditional uses, twenty – five isolated bioactive phytochemicals, their bioactivity and medical/healthcare applications.

**Keywords:** Corn silk; Traditional uses; Phytochemicals; Healthcare application; Toxicity

### 1. Introduction

Herbs which have been employed for centuries in curing several ailments play a major function in forming the basic platform and template of conventional medicines [1]. The healing effects of different traditional herbs are as a result of the presence of bioactive phytochemicals [2]. One of these herbs is corn silk (*Stigma maydis*). Corn silk is produced from stigmas, the thread like strands from the female flower of maize which is yellowish in colour. It is a waste material from the cultivation of corn and it is abundantly available [3]. The corn silks are elongated stigmas which resemble a tuft of hairs. Initially, from colour point of view, the corn silks are usually light green which later changes into light brown, red or yellow. The role of corn silk is to capture the pollen for pollination. Each corn silk may be pollinated to yield a kernel of corn. With regards to length, corn silk can be at least 30 cm long with a faintly sweetish taste. Corn silk is harvested just prior to pollination for medical purposes and can be utilized in fresh or dried form. Corn silk reflects the soft, fibre-like growth which accompanies the ear of the corn [4]. This yellowish thread-like strands or tassels called stigmas are found inside the husks of corn. Corn silk is deemed as a maize (corn) waste by product and it is often under-utilized. Maize being the third most planted food crop and one of the major energy sources, it is also one of the essential cereal and edible grain that the world possesses. The flowers of corn are monoecious, and the male flowers called tassels produces yellow pollens while the female flowers produce corn silk. The silks function as a stigma of a female flower and as the fruit develops, the silk elongates beyond the cob covering the edible part of the plant [1]. *Zea mays* stigma (Corn silk) is the name of the long styles and stigmas on flower pistils. The stigmas are fine and soft, yellowish to green threads of female flowers. Maize (*Zea mays* L.), belonging to family Poaceae, is the third important cereal crop worldwide. It is used as human food, animal feed, and raw material for manufacturing a number of industrial products

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and is considered a potential valuable biofuel and forage crop. The review cross examined the isolated phytochemicals from the corn (maize) silk and their applications in healthcare system.

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## 2. Traditional Uses of Corn Silk

Corn silk has been reported to have a number of orthodox applications. It has been consumed for a long time as a therapeutic remedy for various illnesses and is important as an alternative natural-based treatment [5]. It has been used as traditional medicine in many parts of the world such as China, Turkey, United States, France and Nigeria amongst other nations. Corn silk has been used as diuretic (containing chemicals that work like water pills), antilithiasic, uricosuric and antiseptic and for the treatment of cystitis, gout, nephritis, tumor, hepatitis, edema, kidney stones, diabetes (as it can also alter blood sugar levels), helpful in reducing inflammation, prostate disorder/ prostate problems/prostatitis, urinary tract infections, bedwetting, obesity, malaria, heart problems [6,7,8,9,10]. It soothes and relaxes the lining of the bladder and urinary tubules, hence reducing irritation and increasing urine secretion [11]. It has anti-fatigue and anti-depressant activity and kaliuretic potential [12], as well as excellent antioxidant capacity [5]. It was discovered to demonstrate protective effects in radiation and nephrotoxicity [13], lowers high blood pressure (by reducing fluid retention in the body and also by eliminating toxins which could relieve symptoms of gout, edema, arthritis and promotes relaxation). Corn silk is also used to cure hypercholesterolemia, urinary infections associated diseases [14] and it is found to be effective for weight loss and employed against obesity as well as carpal tunnel syndrome. It improves symptoms of PMS, such as tenderness of breasts [15]. Corn silk was reported to have anti-ulcerogenic activity in Ibibio traditional medicine and also anticonvulsant activity [16,17]. It is an excellent source of fixed and volatile oils, steroids such as sitosterol, stigmasterol, alkaloids, saponins and other natural antioxidants such as flavonoids as well as having other beneficial effects on health. To date, there are various corn silk commercial products for medicinal uses that are available in the market [18] for herb treatment of hypertension, tumor, hyperglycemia, hepatitis, cystitis, gout, kidney stones, diabetes nephritis and prostatitis, urinary tract ailments, including bed-wetting, painful and frequent urination, bloating, liver problems, gravel in the bladder and chronic cystitis, urethritis (and other prostate disorders) [15].

Furthermore, corn silk also works as a gentle detoxifying remedy for the body system. Naturopaths have used corn silk extracts for gonorrhoea treatment and all serious conditions of the urinary passage. It is found to condition the skin and hair and is often an important component of skin and hair products [15]. Corn silk is also used as an important ingredient in development of various drugs [19]. Previous toxicological study on corn silk crude aqueous extract has shown that it does not show any toxic effect on the hematopoietic systems of Wistar rats. It has been discovered to be non-toxic and is safe for human consumption. It is used in tea as a healthy and medical drink in Asia [10,20]. Corn silk water based infusions have been shown to have immune stimulating properties in animal studies with a stimulation of interferon production (a key substance in the body's response to infections). There was also an observation made where there was increased production and movement of specialized white blood cells, called macrophages that could engulf foreign particles. Laboratory studies have also indicated that corn silk is able to inhibit certain bacteria from sticking to the lining of cells as well as it reduces certain cancer forming compounds. Corn silk is a completely safe herb to employ in large or frequent doses when needed. Extracts of corn silk are of several benefits to the old and young as well as to the pregnant and breast feeding women [15]. Silk of Corn can be employed in the form of a tincture, decoction, or can be consumed in form of capsules in order for its phytoconstituents to exert desired and particular bioactivities or healings.

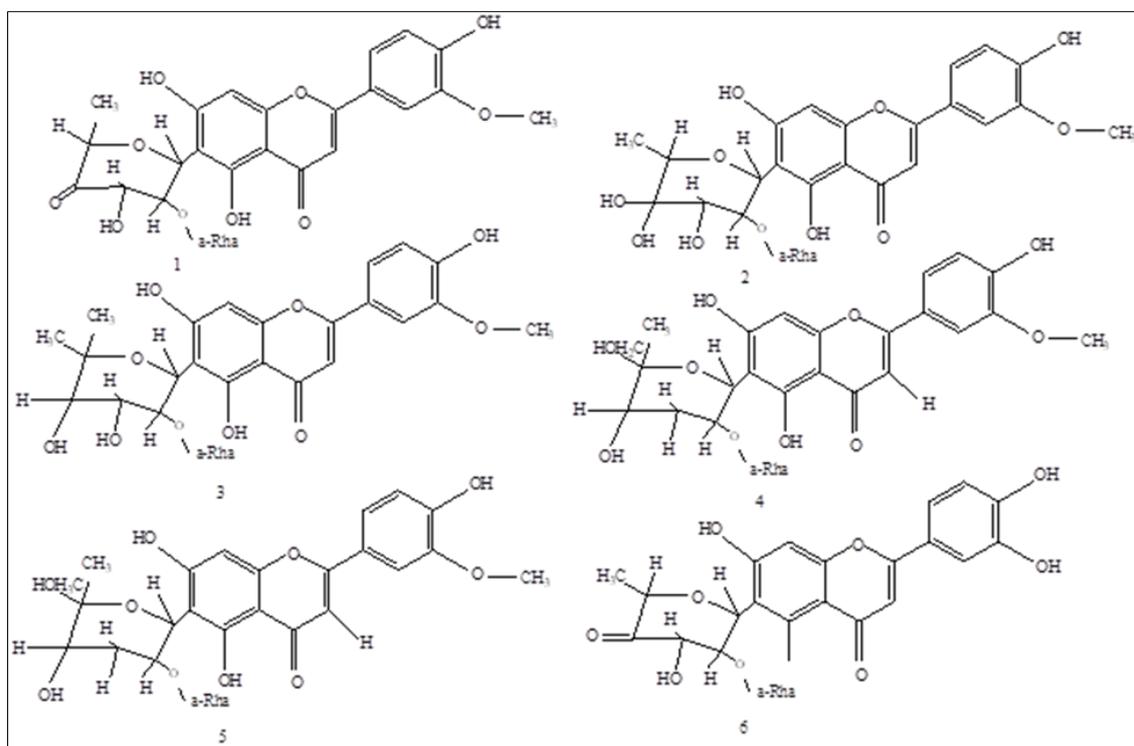
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## 3. Phytochemical Constituents Isolated in Corn Silk and their Medicinal Applications

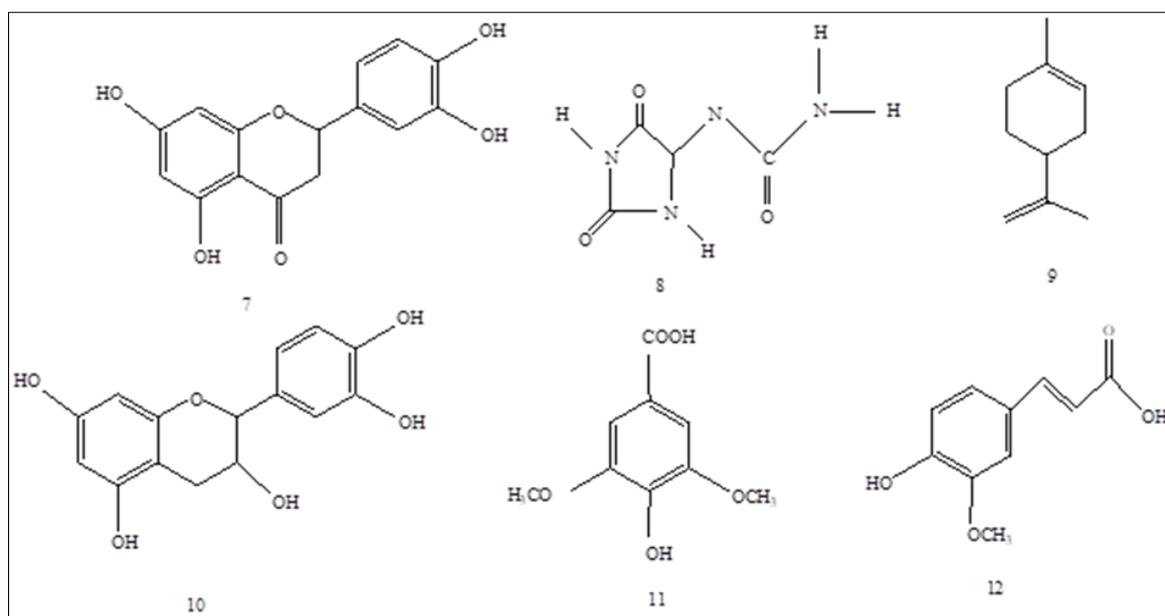
Phytochemicals are the non-nutritional bioactive compounds found in various parts of plants. In plants these compounds perform vital functions particularly protection from predators and harsh environmental conditions. These compounds are also important in pharmaceutical and medicinal field due to their antioxidant, antimicrobial and other biological properties. 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 and volatile oils [21] which have been isolated, characterized and investigated for their biological activities and pharmaceutical functions.

Ren *et al* [22] isolated and identified five flavones glycosides namely: 7,4'-dihydroxy 3'-methoxyflavone-2''-O- $\alpha$ -l-rhamnosyl-6-C-fucoside) (1) , 6,4'-dihydroxy-3'-methoxyflavone-7-O-glucoside – a yellowish green crystal which is soluble in methanol, (2), ax-4''-OH-3'-methoxymaysin (3), ax-5'-methane-3'- methoxymaysin (4) and 2''-O- $\alpha$ -l-rhamnosyl-6-C-3''deoxyglucosyl-3'-methoxyluteolin (5) (a grayish white powder which is soluble in methanol) from the corn silk exhibited antioxidative and scavenging activity. Maysin (6) which was extracted as a flavone glycoside

[22,23,24] encompassing luteolin which was found to disclose antioxidant activity, and has capacity to reduce fat deposition and body weight. Another flavonoid present in and isolated from corn silk known as luteolin (7) [26,27] has been known to exert anticancer activities on UVB-irradiated mouse epidermal cells by suppressing cyclooxygenase (COX) expression, NF- $\kappa$ B activity, anti-oxidative and anti-inflammatory effects [28,29,30]. Khanpour and Modarresi [30] obtained allantoin (8) by LC-MS/MS analysis shows anti-cancer, anti-oxidative and anti-inflammatory effects as well as it is being used to treat skin cancer and promote wound healing. Limonene (9) which exhibits antioxidant activity and anticancer activity was also isolated [32,33].



**Figure 1** Phytochemical Constituents Isolated from Corn Silk 1

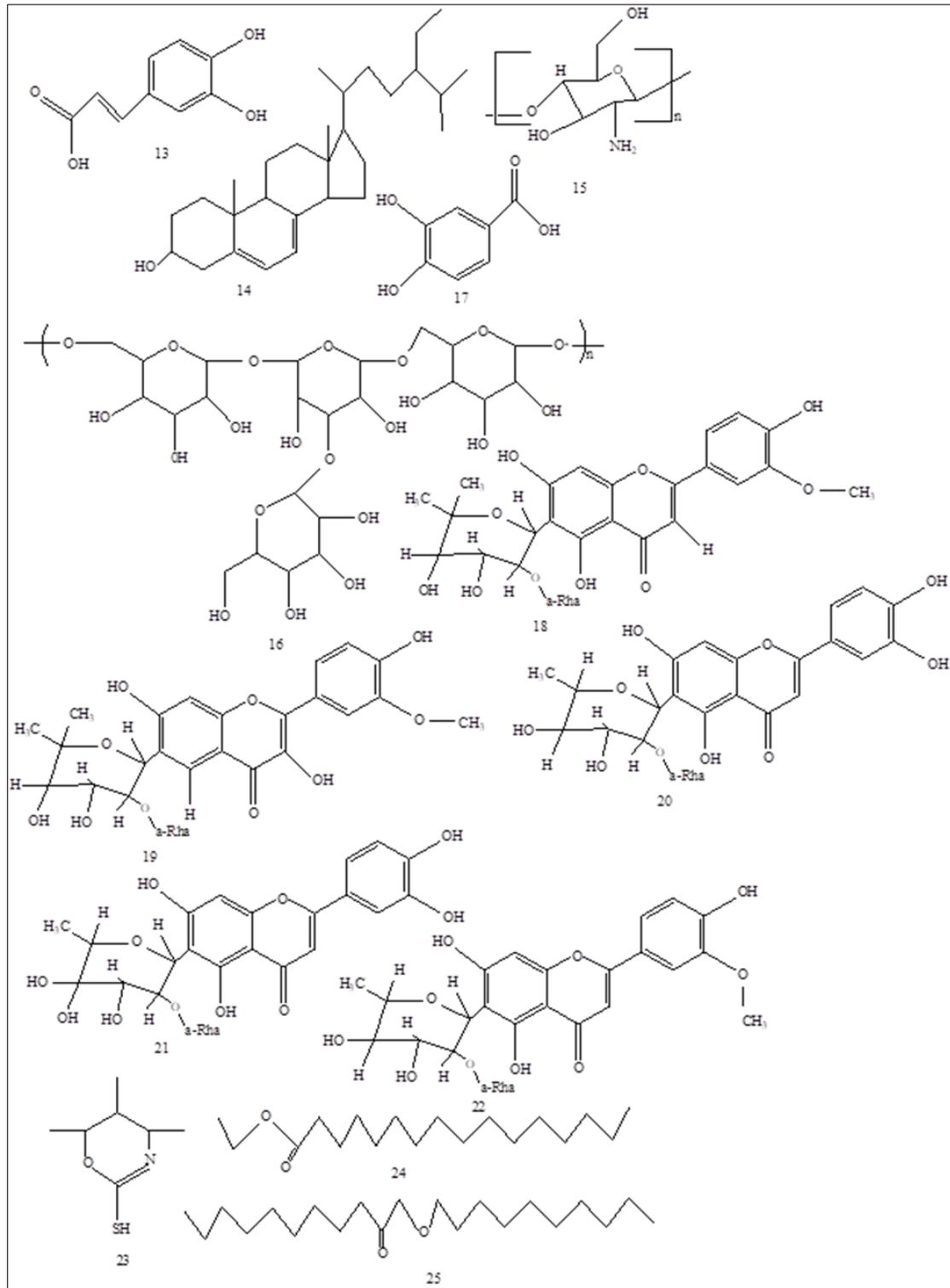


**Figure 2** Phytochemical Constituents Isolated from Corn Silk 2

Furthermore, Jung *et al* [34] isolated catechin (10), a flavonoid from corn silk which was considered and reported to indicate anticarcinogenic activity. Corn silk antioxidant activity [35,36,37], antimutagenic effects [38,39,25] and some other biological properties [40,41] were reported. Syringic acid (11) was extracted by [42,43], ferulic acid (12) with IUPAC name, (*E*)-3-(4-hydroxy-3-methoxy-phenyl) prop-2-enoic acid by [44,45] and caffeic acid (13) from corn silk that have been proven to possess antioxidant property [38,39,25], anti-carcinogenic activity [35,36,37] and anti-mutagenic potential [40,41]. In the same vein, ferulic acid (12) has also been reported to indicate anti-inflammatory, antiviral, antiallergic, antimicrobial, anti-coronary disease, lowering cholesterol, antithrombotic, increasing sperm viability and hepatoprotective actions, directly or indirectly [46,47]. Corn silk being a phenolic acid of low toxicity can be absorbed and easily metabolized in the human body. Ferulic acid can be prepared by chemical synthesis and through biological transformations. As polysaccharide, ferulate is a natural and abundant source of ferulic acid, preparation of ferulic acid from plant cell wall materials will be a prospective pathway [47].

Caffeic acid, compound (13) also displayed antibacterial, antiviral, anti-inflammatory, anti-atherosclerotic, immunostimulatory, antidiabetic, cardioprotective, antiproliferative, antimicrobial, antiobesity hepatoprotective, anti-hepatocellular carcinoma activities [49,50,51,52,53,54]. Stigmasterol (14) was extracted from corn silk [55] and was discovered to exhibit anti-hypoglycemic activity, anti-osteoarthritic, anti-inflammatory, analgesic, anti-cardiovascular, antibacterial, anticancer and antioxidant activities. Stigmasterol (14) [56] was also reported to show antiviral, antifungi, hepatoprotective, antidiabetic, ascaricidal activities, positive modulatory effect on CNS and immunomodulatory effect. Chitosan (15) and dextran (16) were discovered to be present in water extract from corn silk [57] and both inhibited *Aspergillus*' growth or disclosed antibacterial activity. Also, Chitosan, compound (15) showed anticholesterol, antioxidant, anti-inflammatory, analgesic, antitumor, antifungal, antiplasmodial, antihyperglycemic and wound healing activities [58,59,60,61,62,63]. Gallic acid (17) was isolated from the silk of Corn (Maize) [42,43] and was found to display several activities such as therapeutic activities in neuropsychological, gastrointestinal, cardiovascular and metabolic disorders, anti-inflammatory, antioxidant and antineoplastic activities. This compound has been reported to have therapeutic activities in gastrointestinal, neuropsychological, metabolic, and cardiovascular disorders. Isoorientin-2''-*O*- $\alpha$ -L-rhamnoside (18) and 3'-methoxymaysin (19) being two flavones glycoside were found to be present in corn silk ethanol extract (95%) [24,25,64,65] was isolated and properly identified, of which 3'-methoxymaysin/maysin-3'-methyl ether which was also isolated from *n*-butanol fraction of methanol extract of corn silk [65] and was discovered to exhibit free radical scavenging activity and antioxidant activity (the same effect as maysin - 6) and antimicrobial/antibacterial activity against twelve bacteria and one yeast [65] while Isoorientin-2''-*O*- $\alpha$ -L-rhamnoside exerted anti-cancer and anti-oxidant activities.

The antimicrobial activities of maysin (6) and maysin-3'-methyl ether (19) were studied against twelve bacteria and a yeast. The sensitivity of the two compounds (2.0 mg/mL) towards bacteria was compared with that of standard gentamycin (50  $\mu$ g/mL). Flavonoid glycosides disclosed a wider range of activity towards Gram-negative bacteria and Gram-positive bacteria. Comparatively, compound (6) exerted the strongest antibacterial activity towards Gram-positive bacteria than compound (19). In comparison with gentamycin, compound 6 indicated significantly higher activity against the tested bacteria except *Enterobacter aerogenes*, *Salmonella paratyphi*, and *Proteus mirabilis* where it show similar activity with gentamycin, but exhibited lower activity towards *Pseudomonas aeruginosa* than gentamycin. Maysin-3'-methyl ether (19) showed comparatively lesser activity than compound 6; it appears that the presence of methoxyl substitution on the C-3' position slightly decreases the sensitivity towards bacteria [65]. The isolation of 2''-*O*- $\alpha$ -L-rhamnosyl-6-C-quinovosylluteolin (20), 2''-*O*- $\alpha$ -L-rhamnosyl-6-C-fucosylluteolin (21) and 2''-*O*- $\alpha$ -L-rhamnosyl-6-C-fucosyl-3'-methoxyluteolin (22) shows that they exhibited anti-oxidant activity [25]. Also, the extraction of compounds 4.4.5.6-tetramethyltetrahydro -1, 3 - oxazin - thione (23), ethylhexadecanoate (24) and decyl decanoate (25) [66] were reported to reveal antibacterial, skin moisturizing and antioxidant properties respectively.



**Figure 3** Phytochemical Constituents Isolated from Corn Silk 3

#### 4. Conclusion

Corn silk has great medicinal benefits as a result of the presence of several bioactive phytochemical compounds. The presence of these phytochemicals makes corn silk medicinal and enables it to show various biological activities such as anti-oxidant, anti-bacterial, anti-diabetic, anti-fatigue amongst others as well as have some medical applications. This review covered twenty-five phytons isolated from maize (corn) silk and the importance of corn silk and its phytochemicals in healthcare system are justified as safe and natural which do not produce any health threatening side effect due to their chemical structures and of which their importance have been gaining ground so much among all other popular and vital plant herbs and phytochemicals. In years to come, in-depth exploration of the structure-activity relationship of corn phytochemicals should be embarked on and the benefits of multiple sciences should be employed to give a strong scientific basis for the further production of effective and natural new drugs, which should also serve as basis for the full harnessing, development and utilization of phytochemical resources from corn silk. By evidence-based scientific research, active phytochemical constituents present in the silk of corn (maize) should consistently and continuously be used in the preparation of pharmaceutical drugs which are much essential and needed for therapeutic intervention.

#### Compliance with ethical standards

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##### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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