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Zea mays: From Diet to Drug

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Review Article

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ABSTRACT

The world's most significant cereal crop is maize (*Zea mays* L.). It's a good source of both nutrients and phytochemicals. Mays means 'life giver,' while Zea means' sustaining life.' *Zea mays* is one of the world's oldest and most dynamic crop species, and its use in a variety of recipes has made it popular in the modern world as well. Corn-based foods such as cornmeal, maize flakes, popcorn, "makki ki roti," and corn soup demonstrate the crop's global domination. As a result, maize has become a craze among young people nowadays. It's a nutrient-rich, well-drained annual monoecious sunny plant. From the husk to the corn silk, every part of the maize is useful to society. Corn products can be used in over 3,500 different ways. Secondary metabolites such as alkaloids, flavonoids, saponins, maizenic acid, vitamins B1, K, and minerals like as potassium, phosphorus, and zinc are found in the plant. Because of the presence of Galanthus nivalis agglutinin (GNA) lectin or GNA-maize, it is thought to have anti-HIV activity.A healthy child or adult requires only a spoonful of maize oil to meet their necessary fatty acid needs. Maize has long been used as an anti-diarrheal, anti-prostatitic, anti-lithiasis, anti-tumor, anti-hypertensive, anti-diabetic, anti-hyperlipidemic, anti-inflammatory, and anti-oxidant. Decoction of maize silk, roots, leaves, and cob are used for bladder problems, nausea, vomiting, and stomach complaints. In this review paper, we described the pharmacological activities, phytoconstituents, nutritional value, and traditional uses of corn varieties, as well as their pharmacological activities, phytoconstituents, and nutritional value. Maize has a wide range of applications, including culinary, medical, and industrial.

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INTRODUCTION

The world's most important annual grain crop, maize (*Zea mays* L.), is a member of the Poaceae family. Mays is a phrase from the Taino language that means "life giver." Zea is an old Greek word that means "to preserve life." The word "maize" is derived from the Spanish word "maiz," which best describes the plant. The plant is also known by various names such as zea, silk maize, makka, and barajovar. Maize

is the American mother grain and is thought to be the first cultivar of the New World. It is the most extensively dispersed plant on the planet. Thousand s of maize subspecies are identified and categorised based on the amount of starch they contain (Pipernoand Flannery, 2001). Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Haryana, Maharashtra, And hra Pradesh, Himachal Pradesh, West Bengal, Karnataka, and Jammu and Kashmir are the major maize-growing states in India, accounting for about 95 percent of the country's maize production (Milindand Isha, 2013). Flavonoids, saponin, tannins, phlobatannins, phenols, alkaloids, and cardiac glycosides are all found in it (Solihah et al., 2012). Maize is a short-lived crop that necessitates warm weather, as well as proper anticipation and maintenance. It's used as cattle feed, human food, and a raw ingredient in a variety of industries (Kumar and Jhariya, 2013). In many regions of the world, it is seen as a necessary food. After rice and wheat, it is the third most important crop in the world (Kumar and Jhariya, 2013). It is a tall annual plant with strong erect stalks and a fibrous root structure, with long narrow leaves alternately placed on opposing sides of the stem (Hartman *et al.*, 1998), In 2013–14, the global maize production was 967 million metric tonnes (MMT), with 23 MMT produced in India (Summit, 2014). Animal feed is made primarily of maize. Cornmeal, grits, starch, flour, tortillas, snacks, and morning cereals are just a few examples of the products made from it. Chapatis, or flat breads, are made with maize flour and are primarily consumed in India's northern states (Mehta and Dias, 1999). It produces ears that are enclosed by numerous husks, which are modified leaves (Simmonds, 1979). The corn husk has been reported to contain arabinoxylan, which has immunological effects (Ogawa et al., 2005). The ash of the cob is used for the treatment of cough (Gill, 1992). Corn silk has traditionally been used to treat urinary tract infections, pathological edoema, asthma, dropsy, and hypertension (Wynn and Fougere, 2007). The corn silk is used as an antidiabetic or diuretic, and decoction of the silk is consumed for the treatment of urinary troubles and gallstones. (Foster and Duke, 1990; Gill, 1992; Abo et al., 2008). Purple corn is a pigmented *Zea mays* L. cultivar that has been grown in the And ean region of South America for generations. This vibrantly coloured grain is used to make "Chicha morada" and "Mazamorra morada," respectively, traditional beverages and sweets (FAO, 2013) but also as a source of natural colorants for tissues staining (Petroni et al., 2014).

The ethanol extract of corn silk inhibited DPPH activity by 84% at a level of 400 µg/mL (El-Ghorab et al., 2007). The phytochemical substances formed from maize and their health effects have recently become a prominent focus of study as more emphasis is directed to the creation of nutraceuticals. As a result, the goal of this review is to explain the primary phytochemical components found in maize, as well as their health-promoting effects, in order to gain a better understand ing of maize's nutritional and health potential and , as a result, promote its consumption.

Figure 1: *Zea mays*

TAXONOMICAL CLASSIFICATION

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Commelinidae
Order: Cyperales
Family: Poaceae
Genus: Zea
Species: *Zea mays*(Biology of maize, 2011).

TRADITIONAL USES

In the traditional system of medicine, maize is found to be effective as an:

- Analgesic
- Astringent
- Anti-allergic
- Emollient
- Against skin rashes
- Against Sore throat
- Anti-angina
- Anti-hypertensive
- Against Biliousness
- Urinary disorders including dysuria, cystitis, Urethritis, Nocturnal enuresis
- Anti-lithiasis
- Anti-diarrheal
- Anti-dysentry
- Anti-tumor
- Anti-prostatitis
- Anti-gonorroheal

THERAPEUTIC USES

- Corn silk is utilized as a medicine in renal problems for both adults and children, in Mexico. It also helps in genito-urinary complaints.
- Corn silk minimizes edema, gout, cystitis and rheumatism, due to its anti-inflammatory property.
- Chief reputation of corn is its potent anti-prostatitis capability.
- Corn lowers LDL cholesterol and guards against cardiac diseases, diabetes and hypertension (Biology of maize, 2011).

INTERNATIONAL SYNONYMS

Croatian: Kukuruz
Arabic: Dhurah, Surratulmakkah
Chinese: Yu mi xu , Yu shushu, Pao mi
Estonian: Mais
Danish: Majs
Dutch: Maïs, Korrelmaïs, Turksetarwe, Turksekoren
English: Maize (UK), Turkish wheat, Field corn, Corn
(USA), Indian corn
Finnish : Maissi
Russian: Kukuruzaobyknovennaia.
French: Maïs, Blé des Indes, Blé de Turquie.
Korean: Ok soosoo
German: Körnermais, EchterMais, Türkisches Korn,
TuerkisherMais,
Italian : Granturco, Granoturco, Formentone, Grano di
Turchia, Mais
Persian: Gaudumemakka.
Japanese: Toumorokoshi, Fiirudokoon.
Malay: Jagong, Jagung (Indonesia).
Portuguese: Milho, Milhoforrageiro
Spanish: Maíz, Maízcomun, Mijoturquesco, Mazorca de Maí
Swedish: Majs
Thai: Khaaophot (Khaophot), Khaaophot on (Baby corn).
Turkish: Kokoroz
Urdu: Anaaj.
Vietnamese: Ngô

INDIAN SYNONYMS

Gujarati: Makai

Bengali: Bhutta
Punjabi: Makai
Hindi: Anaj, Makka, Makaa'i
Malayalam: Cholam, Makkacholam
Telugu: Mokkajanna
Sanskrit: Makkaya, Mahakaya
Tamil: Makkacholam, Mokkaiccoolam (Milind, 2013)

DESCRIPTION

Maize is an annual grass in the family Poaceae and is a staple food crop grown all over the world.

DISTRIBUTION

Maize is a South American crop that is widely grown in India, Thailand, Pakistan and China, as well as in areas of the Philippines. In several provinces and island s, it is regarded as a staple food. It thrives in well-drained, fertile soil in temperate and tropical climates (Mills, 1994).

Stem: The maize plant possesses a simple stem of nodes and internodes.
Leaves: Each internode has a pair of big leaves that total 8–21 leaves per plant. The leaves are linear or lanceolate (lance-like) in shape, with a prominent midrib (main vein) and a length of 30 to 100 cm (11.8–39.4 in).
Flowers: On the plant, the male and female inflorescences (flower-bearing regions) are located separately. The male inflorescence is referred to as the 'tassel,' whereas the female inflorescence is referred to as the 'ear.' The maize ear is a modified spike that can number from one to three per plant.
Maize Grains: The maize grains, or 'kernels', are encased in husks and total 30–1000 per year. The kernels can be white, yellow, red, purple or black (Gunjan *et al.,* 2021).

CHEMICAL CONSTITUENTS

Table 1: Chemical constituents according to category (Siyuan et al., 2018)

Compounds	Example
Phenolics	Phenolics acids (a) Hydroxybenzoic acid: vannilic acid and syringic acid (b) Hydroxycinnamic acid: p-courmaric, ferulic and caffeic acids
	Flavonoids: Anthocyanins: perlargonidin-3-glucoside, cyanidin-3-glucoside, delphinidin-3-glucoside, peonidin-3-glucoside, petunidin-3-glucoside, and malvidin-3-rutinoside
Carotenoids	Carotenes: β-carotene, α-carotene and β-cryptoxanthin
	Xanthophylls: lutein, zeaxanthin and β-cryptoxanthin
Vitamin E	α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol
Phytosterols	Sitosterol , campestanol, Stigmasterol, delta 5-avenasterolare
Lignins	lariciresinol, matairesinol, pinoresinol, and secoisolariciresinol

Table 2: Chemical constituents according to plant parts (Breadley, 19992; BP, 1983)

Plant part	Phytoconstituents
Seeds	B1 (thiamine), B2 (niacin), B3 (riboflavin), B5 (pantothenic acid) and B6, vitamin C, A and K, beta-carotene, selenium, protein and fat, saponin, allantoin, sterol, stigmasterol, alkaloids, hordenine and polyphenols

Corn silk	maizeric acid, fixed oils, resin, sugar, mucilage, salt and fibres, saponin, allantoin, sterol, stigmasterol, alkaloids, hordenine and polyphenols
Leaves	saponin, allantoin, sterol, stigmasterol, alkaloids, hordenine and polyphenols

PHARMACOLOGICAL ACTIONS OF *ZEA MAYS*

- **Antidiabetic activity**

Okokon et al., (2018) evaluate the antidiabetic activity of *Zea mays* husk extract and fractions (187–748 mg kg^{-1}) in alloxan-induced diabetic rats. The levels of fasting blood glucose (FBG), serum insulin, and lipids were all measured. The extract/fractions reduced FBG in diabetic rats, with the dichloromethane fraction showing the best activity. Serum insulin levels were also raised as a result of the extract/fractions. In the treated diabetic rats, histology of the pancreas revealed no or reduced pathological symptoms (Okokon*et al*., 2018).

- **Antidepressant activity**

Okokon *et al*., (2016) evaluate the antidepression effect of *Zea mays* L. (Poaceae) husk extract(187-748 mg/kg) in mice using open field, force swimming and tail suspension tests. In an open field test, husk extract significantly increased mice's line crossing, walling, and rearing activities (P<0.05-0.001), while also reducing immobility time in a force swimming test (P<0.05-0.001). The extract, on the other hand, significantly prolonged immobility duration in tail suspension tests (P<0.05-0.001). Its phytochemical constituents, such as phenolic chemicals, may be responsible for its antidepressant effects (Okokon *et al*., 2016).

- **Anti-inflammatory activity**

Roh *et al.*, (2016) evaluate the anti-inflammatory effects of Z. *mays*husk extract (ZMHE). To assess the anti-inflammatory activities of ZMHE, examined effects of ZMHE on nitric oxide (NO) production, and release of soluble intercellular adhesion molecule-1 (sICAM-1) and eotaxin-1. Western blot and luciferase reporter assays were used to evaluate the expression level of the inducible nitric oxide synthase (iNOS) gene. In RAW264.7 cells, ZMHE reduced the generation of NO produced by lipopolysaccharide (LPS). Furthermore, Western blot and luciferase reporter experiments indicated that iNOS gene expression was decreased. In addition, ZMHE inhibited LPS-induced sICAM-1 synthesis as well as IL-4-induced eotaxin-1 production. Finally, the study discovered that Z. *mays*husk extract has anti-inflammatory effects via blocking NF-kB and AP-1 signalling and down regulating the expression of the iNOS gene (Roh et al., 2016).

- **Antimicrobial activity**

Nessa*et al*., (2012) investigate the antimicrobial activities of different solvent extracts, flavonoids of corn silk and compare the activities with stand ard antibiotic gentamycin. Corn silk extracts (25 mg/mL) in petroleum ether (PECS), chloroform (CECS), and methanol (MECS) were examined for antibacterial activity. Twelve pathogenic bacteria were used to investigate the antimicrobial activities of the extracts: *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Enterobacteraerogenes, Salmonella typhi, Salmonella paratyphi, Escherichia coli, Shigellasonnei, Shigellaflexneri, Proteus vulgaris, Proteus mirabilis* and one yeast *Candida albicans* were used to investigate the antimicrobial activities of the extracts.The reference antibiotic was gentamycin (50 g/mL). The antibacterial activity of two isolated

flavonoid glycosides (2.0 mg/mL) from maize silk was investigated. The agar hole-plate diffusion method was used to determine the microbial growth inhibitory potential. PECS, MECS, and flavonoids were found to be effective against eleven of the twelve microorganisms tested. Only five microorganisms were resistant to CECS. Against Escherichia coli and Cand ida albicans, no extracts or flavonoids were responsive.The findings were compared to gentamycin, which was found to be effective against all of the microorganisms examined.Extracts and flavonoids showed significantly ($p<0.05$) higher sensitivity against a number of bacteria than gentamycin (Ness*aet al*., 2012).

- **Anticancer activities**

Balasubramanian and Padma (2013) investigated the ability of the different extracts (aqueous, methanol, and chloroform) of the leaves of *Zea mays* in influencing the process of apoptosis induced by hydrogen peroxide (H_2O_2) in Hep2 (laryngeal carcinoma) cells. Cell viability, morphological changes, nuclear modifications, and the apoptotic index were among the apoptosis-related parameters studied. Using sulforhodamine B and MTT tests, the degree of cell death in the group exposed to H_2O_2, plant extracts, and their combination was determined. In cancer cells, H_2O_2 treatment caused cytotoxicity. . The administration of leaf extract also resulted in an increase in cancer cell death. All of the Z. *mays*leaf extracts (save the chloroform extract) showed comparable cytotoxicity to the H_2O_2-treated groups in oxidatively stressed cancer cells.This meant that the cytotoxic activity of H_2O_2 in cancer cells was unaffected by the aqueous and methanol leaf extracts. As a result, different apoptosis-related events in Hep2 cells treated to leaf extract provide light on the Z. *mays*leaves' potential anticancer activities.Methanolic extract had the highest activity, followed by aqueous and chloroform extracts (Balasubramanian and Padma., 2013).

- **Anticataract activity**

Thiraphatthanavong et al., (2014) determine the anticataract effect of *Zea mays* L. (purple waxy corn) in experimental diabetic cataract. Enucleated rat lenses were cultured for 72 hours at room temperature in artificial aqueous humour containing 55 mM glucose and different doses of *Zea mays* L. (purple waxy maize) ranging from 2, 10, and 50 mg/mL. Lens opacification, MDA level, and SOD, CAT, GPx, and AR activities in the lens were all evaluated at the end of the incubation period. The results revealed that both medium and high doses of extract reduced lens opacity while also lowering MDA levels. Furthermore, a medium dose of extract boosted GPx activity whereas a high dose reduced AR activity. There were no other noticeable alterations. The purple waxy corn seeds extract has been proposed as a possible cand idate for diabetic cataract protection (Thiraphatthanavong et al., 2014).

- **Hepatoprotective activity**

Udobang *et al.*, (2019) investigated the husk extract of *Zea mays* (187-748 mg/kg) for hepatoprotective potential against carbon tetrachloride (CCl4)-induced liver injuries in rats. The hepatoprotective properties of husk extract were evaluated using assays of liver function parameters and a histological investigation of the liver. In all of the models, administration of the husk extract (187-748 mg/kg) resulted in significant (p0.05-0.001) reductions in liver biomarker enzymes (ALT, AST, and ALP), direct and total bilirubin, and an elevation of serum total protein levels.In the majority of cases, the effects were dose-dependent. When comparing the pathological features of extract and silymarin-treated animals to those of organotoxic-treated animals, histology revealed that the pathological features of extract and silymarin-treated animals were

reduced. The chemical pathological changes were in line with histological findings, implying significant hepatoprotective potential.The findings revealed that *Zea mays* husk extract possesses hepatoprotective properties against harmful agents, which could be attributable to the actions of its phytochemical components (Udobang et al., 2019).

- **Nephroprotective activity**

Okokon et al., (2017) evaluated*Zea mays*husk for antioxidative stress and reno protective potentials against alloxan-induced injuries in diabetic rats. The antioxidative stress and renoprotective properties of husk extract and fractions (187-748 mg/kg) were determined by measuring oxidative stress indicators, kidney function tests, and kidney histology. The HematologyAnalyzer was used to determine haematological parameters. In the treated diabetic rats, the husk extract and fractions generated significant ($p<0.05$) increases in oxidative stress markers (SOD, CAT, GPx, GSH) in the kidney, as well as a decrease in MDA levels. In diabetic rats, the extract and fractions reduced high serum creatinine, urea, and chloride levels by a considerable ($p < 0.05$) amount. WBC, PCV, monocyte, neutrophil, platelet, and eosinophil counts all increased in response to the extract/fractions, but other parameters remained unchanged. When comparing treated diabetic rats to untreated diabetic rats, histology of the kidney indicated no or considerable reductions in abnormal characteristics. The existence of phytochemical substances of pharmacological relevance was discovered using GC-MS analysis of the n-hexane fraction. The findings revealed that *Zea mays* husk extract and fractions have antioxidative and nephroprotective properties, which could be attributed to the antioxidant activities of their phytochemical contents (Okokon*et al.,* 2017).

- **Antiulcerogenic activity**

Okokon et al., (2018) evaluated for antiulcerogenic activity of husk extract of *Zea mays*. *Zea mays* husk is used in Ibibio traditional medicine for the treatment of various ailments including diabetes mellitus, malaria and ulcer. The antiulcerogenic effect of ethanol husk extract of *Zea mays* (187-784 mg/kg) against indomethacin, ethanol, and histamine-induced ulcers in rats was investigated. Indomethacin, ethanol, and histamine-induced ulcers were shown to be significantly ($p<0.05$ -0.001) inhibited by the husk extract in a dose-dependent manner. These findings imply that the phytochemical elements in *Zea mays* husk extract have antiulcerogenic properties (Okokon et al., 2018).

- **Hypoglycemic and hypolipiodemic activities**

Ghada et al., (2013) evaluated the hypoglycemic effect of methanolic extract of corn silk in vivo using albino rats for both type I and type II. The methanolic extract has a substantial hypoglycemic impact ($p<0.05$) in type-II glucose-loaded diabetic rats and cholesterol ($p<0.05$) in streptozotocin-induced type-I diabetic rats at dosages of 200 mg/kg and 400 mg/kg. Corn silk's hypoglycemic impact in type I diabetes could be related to beta-cell regeneration, as evidenced by the rise in insulin production reported during the study. Thin Layer Chromatography (TLC) was used to screen phytochemical groups, and favourable findings were found for flavonoids, terpenoids, sesquiterpene lactones, and saponins. Corn silk has the potential to be used as an anti-diabetic drug, according to research. As a result, determining the bioactive compound(s) necessitates additional research (Ghada et al., 2013).

- **Antiobesity activity**

Chaiittianan et al., (2016) investigated corn silk extracts (CSEs) for their phytochemical compositions using HPLC-UV method,

antioxidation using FRAP and DPPH assays and anti-obesity potential in 3T3-L1 adipocyte. Flavonoids as quercetinglucoside derivatives and phenolics as ferulic acid were found in sweet CSEs, whereas phenolics as p-coumaric acid and derivatives of gallic acid were found in waxy CSEs. Sweet CSEs had stronger antioxidant activity, anti-pre-adipocyte proliferation, anti-adipogenesis, and lipolysis induction than waxy CSEs, which could be attributed to their high phytochemical content. Additionally, in sweet CSEs, there were strong associations between phytochemical concentration and anti-proliferation and anti-adipocyte differentiation. Lipolysis was induced in both sweet and waxy CSEs, which was surprising. Finally, CSEs' anti-obesity properties, which include anti-adipogenesis and lipolysis induction, are linked to the functional ingredient's flavonoids and phenolics (Chaiittiananet *al*., 2016).

- **Anti-tumour activity**

Yange et al., (2014) investigated the effects of corn silk polysaccharides (CSP) on tumor growth and immune functions in H22 hepatocarcinoma tumor-bearing mice. The findings showed that CSP not only slowed tumour growth but also increased the survival time of H22 tumor-bearing mice. Furthermore, CSP injection increased the body weight, WBC count, thymus index, and spleen index of H22 tumor-bearing mice. Additionally, CSP therapy increased the production of serum cytokines such IL-2, IL-6, and TNF- in H22 tumor-bearing animals. Furthermore, CSP-treated mice transplanted H22 tumour cells showed no toxicological effects on hepatic or renal function. In conclusion, our study found that CSP might boost immune activities in H22 tumor-bearing mice, increasing anticancer activity, and that CSP is a safe and effective treatment for hepatocellular carcinoma (Yang et al., 2014).

- **Analgesic activity**

Owoyele et al., (2010) investigated the analgesic activity of husk extract of *Zea mays* (25, 50, 100, and 200 mg/kg of body weight) in rats. The extract's analgesic properties were evaluated using the hot plate and formalin-induced paw licking models. When compared to the control group, the extract at 25, 50, 100, and 200 mg/kg body weight significantly ($P < .05$) reduced pain stimuli. The formalin reduced paw licking time and granuloma weight in a dose-dependent manner. In all of the experiments, the extract doses of 200 mg/kg generated greater effects than indomethacin (5 mg/kg body weight). These findings imply that the tannins and polyphenolic compounds in *Z. mays*husk extract may have analgesic properties. The use of Z. *mays*husk decoction for the treatment of pain disorders in Nigerian traditional medicine has now been scientifically validated (Owoyele et al., 2010).

CONCLUSION

According to the literature review, corn is valuable not only as food or medication, but even its waste after usage has a number of unique benefits for animals and industry. It was also determined that maize has not yet been properly scientifically examined for its composition and values, and that more research is needed to fully understand this plant for the new era of science.

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Author's Contribution

Deepa Bharti: Planned and wrote the manuscript. Dr. Mohd Aftab Siddiqui and Muhammad Arif: Supervised, reviewed and edited the manuscript. All authors read and approved the final manuscript.

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