



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 1579-1582
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www.thepharmajournal.com
Received: 09-03-2022
Accepted: 24-04-2022

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Corn: A crop with multiple health benefits

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Abstract

Corn or Maize (*Zea mays* L.) is considered as a vital cereal crop, and has been characterized by high production along with high export concentrations at global level, although world is experiencing remarkable trends. In order to ensure the global supply of corn, energy and food security of the nations has become crucial factor to focus. India recorded highest yield in the states of Andhra Pradesh as 6.54 tonnes per hectare during 2015-2016. Corn is a source of nutrition as well as phytochemical rich crop. Prevention of chronic diseases is due to the presence of phytochemicals such as carotenoids, phenolic compounds, and phytosterols. It has been proved that refining corn silks, roots, leaves and cob improves nausea, vomiting as well as stomach complaints and also been effective for bladder problems. Corn has been utilized as food crop (grain maize), and as an important animal feed in many countries such as USA, Brazil. It has also used as a basic compound for ethanol production.

Keywords: Corn, production, varieties, nutrients, phytochemicals, health benefits, uses

1. Introduction

Maize belongs to the family of *Poaceae* or *Gramineae*. The variety is indigenous to Mesamerica, and found as domesticated in Mexico from approx 9,000 years ago. It has spread throughout the mainland of America. At present it has been widely cultivated all over the world. The native corn is comprised of 10, 00 species, categorised as 600-700 different genera. The family also consists of oats, barley and rice. Maize is considered as one of the widely cultivated and consumed worldwide. The utilization of crop is in human consumption, livestock feed and as a raw material for industrial products such as pharmaceuticals, oils, cosmetics, beverages and textiles etc. (Verheve *et al.*, 2010) ^[1]. The corn is also grown for improvement of nutrition in the form of quality protein maize and sweet corn as well as baby corn is responsible for the assurance of the livelihood of farmers (Dass *et al.*, 2012) ^[2]. Therefore, corn has been considered as a key crop for feed and food security, and also a source of income for millions of farmers in Asia, Latin America and sub-Saharan Africa (SSA).

India has been ranked second as most important corn- growing nation in Asia and is the 6th and 5th largest producer and consumer respectively. The rising growth of poultry industry is one of the largest drivers of corn, in which consumption is estimated approximately 13-14 million tons of corn per annum (Prassana *et al.*, 2014). Total crop demand in south Asia can be estimated nearly 19 million in 2020, which indicates 36% rise when compared to the actual demand in year 1997 (ISAAA 2003).

2. Maize Production and varieties in India

Currently, maize has been covered an area of 9.55 million hectares, yields approx. 2.5 tonnes per hectare. It has been regarded as a vital crop after the replacement of traditional crops such as rice, wheat and soybean due to various factors like water scarcity. During the period 1966-2015, area under corn has been increased by 71.40% from 5.07 to 8.69 million ha. The production as well as productivity has also been recorded as increased from 4.89 to 21.81 million tones and 0.96 to 2.5 tonnes per hectare respectively. More than 85% of corn production in the country emerges from 9 states; Andhra Pradesh, Bihar, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Telangana and Uttar Pradesh. In recent years, Tamil Nadu has been observed as one of the major producers. During the year 2015- 2016, highest corn yield was observed in Andhra Pradesh as 6.54 tonnes per hectare, and in Tamil Nadu i.e. 6.06 tonnes per hectare (Nelson *et al.*, 2019) ^[6].

India has been recorded with some improved varieties over the time. At present 65% of corn-growing area is covered under hybrids, out of which 25% of area is allotted to single- cross hybrids (SCHs).

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Around 90% of corn varieties in Andhra Pradesh, Telangana, Tamil Nadu, Punjab, Bihar (Rabi season) and Haryana fall under hybrids (Vasvani *et al.*, 2016) [3]. However, hybrid adoption rate has been observed as low in Rajasthan, Bihar (Kharif season), Chhattisgarh, Madhya Pradesh, Uttar Pradesh and the North- Eastern states (Yadav *et al.*, 2014) [5].

3. Growth and development

On the bases of an altitude and the environment in which it is grown, corn has been classified as tropical corn and temperate corn. Tropical corn is grown in warmer conditions and lies between the equator and 30°N and 30°S. On other hand temperate corn is grown in cold climate, falling beyond 34°N and 34°S. Corn plant in general, grows and develops from a seed to a mature plant in few months. There is variation among plant size, length of growth period as well as yield potential which depends on the region of production. The corn plant is a tall, leafy structure along with a fibrous root system which supports a single shoot with leaves and one lateral branch terminated by a female inflorescence, developing into ear covered by husk leaves as shown in Figure 1. The upper body of the plant develops the male inflorescence and known as tassel. Corn is the only plant in which there is separate inflorescence of male and female can be observed.

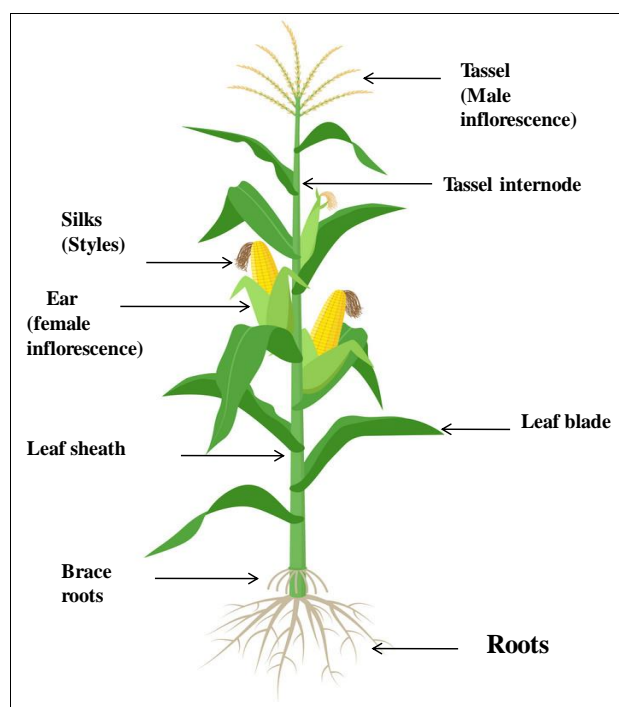


Fig 1: Corn plant showing different parts of the plant

After pollination, the botanical name of kernel or fruit is developed and termed as caryopsis. The corn kernel consists of three major structures pericarp, endosperm and germ. The pericarp is also known as fruit coat and an outer thin- layer which provides protection to the true seed and consists of germ and endosperm is regarded as first and second reserve tissues. The germ contains the embryonic axis along with scutellum and endosperm contains starch granules which serve as the major energy sources at the time of seed germination (Garcia *et al.*, 2019) [25].

Germination

The germination of corn seed takes place between 6 and 15

days after planting under optimal conditions of temperature and humidity. There is a significant time variability which depends on type, temperature and moisture of the soil. The physiology of the germination depends on the phytohormone gibberellins as it contributes in the synthesis of lipases, phytases, many cell wall degrading enzymes, and α and β -amylases are found as essential to generate the necessary energy and nutrients for germination. Radical is the first structure which outbreaks the seed coat, followed by the coleoptiles which is a protective sheath that covers the emerging shoot, after the seminal roots. The growth and elongation of the coleoptiles origin the plant which emerges from the soil (Serna and Saldivar, 2010) [7].

Vegetative development

The vegetative phase of plant continues the growth of seminal root system, which emanated from the seed and continuous to the nodal root system. The role of seminal roots is of water absorption at least for the first week of life of the new plant. All the nutrients needed by the new plant raised from the endosperm, which stored food reserves during seed development. The nodal roots develop and root system also achieve the better depth in the mid of the reproductive stage which occurs approx 3 months after emergence. New leaves and roots develop from the growing point termed as apical meristem. The development of corn plant in its lifespan is found close to 30 leaves, start producing silk around 2 months and attain the physiological maturity stage after 3 months. Under optimal conditions, emergence of new leaf after very 3-4 days until tassel emerges which indicates the attainment of full height. The latter phase of the vegetative stages reflects very rapid leaf- area formation as well as reproductive development. It is important to note that there is time variability present in between the growth stages factors such as plant maturity, planning date, location and the photoperiod (Troyer *et al.*, 2000) [8].

Pollination and kernel development: Corn is a monoecious plant, i.e. staminate flowers are tassel and the pistillate flowers act as ear shoots. The separation of inflorescence allows auto as well as cross pollination and a key idea in order to improve the corn by maize geneticists or breeders. The presence of anthers is in each stamen and the 'anthesis time' which is the period during a flower in which flower is fully open and active. The expulsion of anthers occurs and the pollens escape. It has estimated that tassel has potential of producing between 2 and 5 million pollen grains per plant. In relation to the ear, each ovule produce a fiber, termed as silk, an elongation of the style and linked with an individual ovary. An ear has potential to produce around 600 to 1000 silks. The shedded pollens from the tassel's end fall on these silks. The germination of single pollen grain takes place on each silk and pollen tube develops which grown down the silk until ovary got fertilized. After fertilization, development of corn or post silking stage ear takes place which is identified as blister, milk, dough, dent, and physiological maturity. This stage normally takes upto 65 days to reach from silking to physiological maturity (Josipovic *et al.*, 2007) [9].

4. Health benefits of corn

Corn ensures ample of health benefits, and are tabulated in Table 1. The vitamin such as B-complex vitamin present in corn is validated for the betterment of skin, hair, heart, brain

and for better digestibility. Other vitamins such as vitamin A, C, and K along with beta- carotene and selenium are better known for improving immune system and thyroid function. Potassium present in maize is well known for its diuretic effect. Corn silk has variety of health benefits associated with it (Rouf shah *et al.*, 2016) [24] It has been utilized in the treatment of kidney stones, urinary tract infections, and jaundice in many countries such as India, China, France, Spain and Greece. It is a potent component which improves blood pressure, diabetes, better liver functioning. Refined corn leaves, roots, cob and silks also contribute in improving nausea, vomiting, bladder issues and stomach upset (Kumar & Jhariya, 2013) [10].

The essential fatty acids present in corn especially linoleic acid is a potent diet component which aids in the regulation of

blood pressure, blood cholesterol levels and prevent heart diseases (Zielinski *et al.*, 2008) [11]. Vitamin E is a proved antioxidant vitamin, helps in the prevention of oxidative stress and decrease the risk of atherosclerosis (Zhang *et al.* 2010) [12]. Resistant starch present in corn act as dietary fiber, which helps in the management of weight control (Deng *et al.*, 2010) [23]. It leads to reduce the food intake by modulating the gene expressions. A study stated that adding resistant starch from corn in daily diet of rats shown improved energy balance via stimulating gut peptide tyrosine- tyrosine (peptide YY) which express glucagon peptide- 1 and some other genes in the hypothalamus of the brain. These genes represent as key factors in maintaining the energy homeostatis as well as reduction in food intake by enhancing the satiety (Bishop *et al.*, 2011; Shen *et al.*, 2009) [14, 13].

Table 1: Components present in corn providing health benefits

Sr.no	Compounds	Health effect	Reference
1.	Vitamins	Improved skin, hair, heart, brain functioning; Improved immune system, thyroid function Anti- oxidant	Rouf Shah <i>et al.</i> , 2016; Kumar & Jhariya, 2013; Zhang <i>et al.</i> , 2010 [24, 10, 12]
	Vitamin B complex		
	Vitamin A		
	Vitamin C		
	Vitamin K Vitamin E		
2.	Minerals	Diuretic effect	
	Potassium		
3.	Essential fatty acids	Blood pressure regulation, blood cholesterol levels maintenance	Zielinski <i>et al.</i> , 2008 [11]
	Linoleic acid		
4.	Dietary fiber	Weight reduction	Deng <i>et al.</i> , 2010 [23]
5.	Carotenoids:	Anti cancer, antioxidant Anti cancer, antioxidant	Greer <i>et al.</i> , 2009 Liu, 2007; Shahidi, 2009 Moreno <i>et al.</i> , 2007 [21, 15, 16, 22]
	Carotenes, Xanthophylls (lutein and zeaxanthin)		
6.	Phenolic compounds:	Anti cancer, anti- inflammatory, anti diabetic and antihypertensive. Anti- carcinogenic compounds, anti diabetic, anti- atherogenic, anti- inflammatory antimicrobial	Zhao <i>et al.</i> , 2005; Zhang <i>et al.</i> , 2010 [20, 12]
	Ferulic acid (FA)		
	Anthocyanins		
7.	Phytosterols:	Cholesterol inhibition	Jiang and Wang <i>et al.</i> , 2005) [19]
	(Sitosterol, Stigmasterol, Campesterol)		

Corn has been regarded as perfect source of phytochemicals which ensure health benefits. Phytochemicals due to their potent antioxidant properties mark positive outcomes in reducing the risk of health diseases (Saxena *et al.*, 2013) [17]. Corn grain, especially yellow variety has large quantity of carotenoid pigment. This pigment has been marked as beneficial in cancer prevention (Liu, 2007; Shahidi, 2009) [15, 16]. Xanthophylls such as lutein and zeaxanthin present in corn are validated with biological effects. The supplementation of lutein in food is found to enhance tumor latency, inhibits mammary tumor growth, increase lymphocyte proliferation and protects against oxidation damage. Both lutein and zeaxanthin are the only carotenoids which are responsible for the sharp vision and found in the retina. Lutein is a potent chemopreventive suppressing agent due to its inhibitory actions (Moreno *et al.*, 2007) [22]. Phenolic compounds present in corn are ferulic acid (FA) and anthocyanins. Most abundant anthocyanins present in corn are pelargonidin-3-glucoside, peonidin-3-glucoside, pelargonidin-3- (6"-malonylglucoside), cyanidin-3-glucoside, cyanidin-3-(3", 6"-malonylglucoside) and cyanidin-3-(3", 6" dimalonylglucoside). The health benefits extracted from FA is it acts as anti cancer, anti-inflammatory, anti diabetic has also poses hepatoprotective effects (Zhao *et al.*, 2005) [20]. Anthocyanins are well know anti- carcinogenic compounds, act as anti diabetic, anti-

atherogenic, is anti- inflammatory as well as antimicrobial potential (Zhang *et al.*, 2010) [12]. The consumption of phytosterols present in maize has been associated with inhibition of cholesterol and thus contributing in preventing atherosclerotic disease (Harrabi *et al.*, 2008) [18]. The mechanism includes inhibiting cholesterol absorption through intestine and stimulating cholesterol synthesis which results in the elimination of cholesterol in stools. The most commonly consumed phytosterols from maize oil are sitosterol, stigmasterol, and campesterol (Jiang and Wang *et al.*, 2005) [19].

5. Utilization of corn

In contrast to wheat and rice, corn is mostly utilized for animal feeding and, in bioethanol production. Food and Agricultural Organization (FAO, 2016) stats that approx 85% of corn was utilized for animal feeds and bioethanol. Around 320 million metric tons of maize was produced in USA during 2016, in which data indicate that 45%, 42% and 13% used for animal feed, bioethanol and for food/ seed/ industrial purposes respectively. The main purpose of maize is as a food source for animals that provide milk, eggs, and meat products. 70% of the diet includes ground or processed corn, for example steam flaked, extruded corn products. Corn has been preferred as the feedstock as it is easily available, affordable,

palatable and easy digestible and source of essential nutrients such as calcium, iron and vitamin B12. The main utilization of corn is due to as a source of highly digestible energy, although by-products are rich in fiber, fat or protein. It has been observed that maize alone has not potential to sustain growth in most domestic animals in their early stages of development as it is protein deficient. In order to overcome this problem, feeds are now supplemented with legume or oilseed proteins. Thus the corn consumption has been regarded as the most utilized crop from farms to industry.

6. Conclusion

Corn has been regarded as the most relevant and largest production crop. It has been considered a healthy as a food crop due to the presence of nutrients and phytochemicals. The corn has been identified as one and only crop in which inflorescence is separated into male (tassel), and female (ear). The plant has two phases; vegetative phase and reproductive phase. The health benefits extracted from maize has been discussed and indicates that consuming maize in daily diet offers betterment by preventing number of chronic disease. The vitamins and minerals present in maize plant in different parts such as roots, leaves, cob and silks are proved has potent antioxidant, anti-inflammatory, antimicrobial and anti cancer. The phytochemicals as bioactive components plays vital role in preventing risks of life-threatening disorders. From the utilization point of view, corn is mainly used as feed, food or by industries.

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