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Maize Utilization in India: An Overview

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Abstract Maize is cultivated widely throughout the world and has the highest production among all the cereals. It is considered as one of the fastest growing cash crops in the world becoming the largest component of global coarse-grain trade. Maize is preferred staple food for 900 million poor, 120 -140 million poor farm families, and about one-third of all malnourished children globally. With changing global food demands and consumer choices maize is now becoming the wonder crop for many countries especially in developing countries like India. Maize is the third most important food grain following wheat and rice for Indian population. More than half of the total maize production of India is produced in four states of Madhya Pradesh, Andhra Pradesh, Karnataka and Rajasthan. In spite of wide range of health benefits offered by maize as a source of high fiber, antioxidants and other vitamins and minerals, major portion of maize is still not being used for human consumption and goes for poultry and animal feed. In India, even after achieving self-sufficiency in cereals and grains production, about 50 per cent children are still fighting with malnutrition. Maize being the cheap crop, has the potential to be the first choice for poor and underprivileged population. Nutritional and clinical benefits of the maize if exploited well with the strategic interventions through value added maize product development, utilization and commercialization will support in ensuring better health of the Indian population. Availability of value added food products of maize on industrial level will ensure better nutritional and livelihood security. Commercialization, promotion, and adoption of maize based value added food products will not only ensure higher return to farmers but also generate employment for women and youth with improved dietary diversity in food choices to the consumers.

Keywords: *maize, production, Quality Protein Maize (QPM), malnutrition, value addition*

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1. Introduction

Cereal grains are important staple foods providing substantial amounts of energy, protein and micronutrients for much of the world's population. The nutrients in cereals are distributed unevenly throughout the grain and are known to have potential for reducing the risk of Coronary Heart Disease, reducing tumour incidence, cancer risk, lowering blood pressure, reduced rate of cholesterol and fat absorption etc. Thus the diet with regular inclusion of cereals can contribute much to health promotion and disease prevention. The major cereals include wheat, maize, rice, barley, sorghum, millet, oats, and rye. They are grown on nearly 60 per cent of the cultivated land in the world. Wheat, maize, rice etc. are now employed in preparation of foods that are similar in appearance to conventional foods and used in normal diet but have an added advantage of aiding physiological functions along with providing nutrition. It is a good source of many nutrients including thiamine, pantothenic acid, folate, dietary fibre, vitamin, phosphorous and manganese. Corn's contribution to heart health lies not just in its fibre but in the significant amounts of folate that corn supplies. It also contains cryptoxanthin, a natural carotenoid pigment which has the potential to reduce lung cancer. The phenolic content in maize helps in free radical scavenging activity. Historically, demand for the grain was driven by the poultry and starch industries. But with changing food habits, the demand for food additives derived from maize is also growing. The demand for starch is strong and is growing 10 to 12 per cent every year due to rising consumption in the food and pharma industry [1]. Maize starch, an excellent source of carbohydrates, is a highly versatile industrial raw material and finds extensive applications in the textile, food, pharmaceutical and paper industries. Maize is preferred in poultry feed because of its easy availability. India has grown to be the fifth largest egg producer globally and 18th largest producer of broiler chicken. In poultry feed industry maize constitutes about 60 per cent of the feed and therefore is a critical raw material. International maize trade is now larger than the international rice trade. India is one of the beneficiaries of the booming international maize trade. The country exported a record five million tonnes of maize in 2012/13, valued at Rs. 7,000 crore and is now the fourth-largest maize exporter after the US,

Brazil and Ukraine. In the last five years, exports have doubled and by 2025, maize will be the developing world's largest crop and it is expected that the demand for maize in the developing world will be doubled by 2050. Due to its wide applications in variety of products maize is also referred to as the 'Queen of Cereals'. It is found that nearly one-fourth of the stock in a modern grocery store contain maize in one form or the other. Besides as a food source as Maize rich breakfast cereals, cooking oils, snacks and popcorn, the products include from toothpaste, detergent, paper, dyes, soaps to artificial sweeteners, fructose, etc. Maize also finds application in food containers, plastic food packaging, baby powder, diapers, medicine, vitamin tablets, textile products, candies and so on. Internationally, maize has been processed to produce bioethanol in a big way for blending with auto fuels. In fact, maize is the only cereal that has such diverse uses. Maize is the first major cereal crop to benefit from hybridization. Spurring maize production in the country is technological intervention in the form of hybridization. It involves crossing two genetically different plants to produce a desired seed that can grow high yielding plants. The transgenic varieties in India, include HQPM-1, 4,5,7 9, Vivek, Shaktiman-1,2,3,4. Currently, hybrids constitute only about 30 per cent of the area in India under maize compared with 85 per cent in the USA. It is estimated that the area under hybrids will go up to 90 per cent by 2050. In India maize used to be a subsistence crop for the farmers few years ago but with the rising allocation of wheat and rice at affordable prices in the public distribution system at the central as well as the state level, farmers have moved away from maize consumption and it has led to a rise in its marketable surplus. Direct consumption of maize is expected to dip further with rising prosperity levels in rural India. Thus it becomes more imperative to ensure better price discovery of maize. Maize is mostly grown by small and marginal farmers. Hence, improved price discovery and better realization of crops become key in giving a push to maize production in India

Maize can be grown over a range of agro-climatic zones and this quality makes it a versatile crop. Maize is suitable to be grown in diverse environmental conditions which is not possible for any other crop. It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year [3,4] and with a growing cycle ranging from 3 to 13 months [2]. However, the major maize production areas are located in temperate regions of the globe. The United States, China, Brazil and Mexico account for 70 per cent of global production. India has 5 per cent of maize acreage and contributes 2 per cent of world production [4]. The use of maize varies in different countries. Maize is used mainly as a feed for animals directly or sold to industries dealing with feed and fodder and as raw material for extractive/ fermentation industries in the US, EU, Canada and other developed countries, [6,7,8] and [9] whereas main use of maize is for food in Latin America and Africa. In Asia maize is being utilized for human nutrition as well as animal nutrition. In other developing countries utilization pattern of maize is variable. The fact is that maize is being exploited and consumed in many countries and it is an important ingredient in the diets of people. According to an estimate approximately 21 per cent of the total grain produced is consumed as food globally. In Indian Scenario maize is the third most important food grain following wheat and rice. About 28 per cent of maize produced is utilized for food purpose, about 11 per cent for livestock feed, 48 per cent for poultry feed, 12 per cent in wet milling industry (for example starch and oil production) and 1 per cent as seed goes in India [9]. The highest growth rate for the maize has been registered in the last one decade among all food grains including wheat and rice because of newly emerging food habits, consumer awareness about health as well as enhanced industrial requirements.

Two thirds of studies predict decline in overall yield of over 10 per cent by 2050, meaning that developing countries would have to increase maize imports by 24 per cent at an annual cost of US $30 billion. In China, over 30.2 million hectares of prime agricultural land is dedicated to maize production but even this is not enough. China became a net importer of maize for the first time in 14 years in 2011 and by 2015; China is expected to import 15 million tons of maize from the US alone. In 2010, Indonesia imported 1.6 million tons of maize and it is estimated that Indonesia imported 3.2 million tons in 2012. Japan – the world's largest importer of maize – imports an estimated 16 million tons of maize annually. By 2050, global maize consumption is expected to increase from 32 to 52 kilograms per person per year [2]. For industrialized countries, maize shortages and declining yields mean increased prices. However, for developing countries, maize shortages result in increased malnutrition for children, higher rates of poverty for smallholder farmers and extended periods of hunger for families. Positive nutritional and economic features (easy to grow, harvest and store) have made maize a competitive crop, which has helped lower the price of food staples such as meat and dairy products. Rapid increases in poultry consumption in Africa and developing countries is a major factor contributing to the increased use of maize for livestock feed [2].

In India, maize is the third most important food crops after rice and wheat. According to advance estimate its production is likely to be 22.23 M tonnes (2012-13) mainly during Kharif season which covers 80 per cent area. Maize in India, contributes nearly 9 per cent in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in peri-urban areas. The predominant maize growing states that contributes more than 80 per cent of the total maize production are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %), Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. Hence, the maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 m t) and

productivity (5.26 t ha-1) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA.

The demand for maize is spiraling in India. Maize is an important cereal of India and is grown over 4 per cent of the net area sown of the country. There have been large variations in the production of maize in India since Independence. It was only 1.7 million tonnes in 1950-51 which rose to 4.1 million tonnes in 1960-61 and 7.5 million tonnes in 1970-71. Thereafter, the production has been variable till 1984-85 when it further rose to 84.42 lakh tones. The production fell to 57.21 in the drought year of 1987-88. Since then it has been steadily increasing. Year 2003-04 was the record year when all the three aspects of maize viz., production, area and yield were the highest. India produced 14.7 million tonnes of maize from 7.4 million hectares of land with an average yield of 1963 kg/hectare in that year. Maize is grown throughout the year in India though it is predominantly a kharif crop with 85 per cent of the area under cultivation in the season [3]. Maize is the third most important crop after wheat and rice accounts for 9 per cent of total food grain production in the India. The arid lands of Rajasthan are especially suited to maize cultivation where it is grown in Udaipur, Bhilwara, Dungurpur, Chittaurgarh and Banswara districts. Rajasthan has the largest area under maize cultivation and this state gives the lowest yields among all the major maize producing states of India.

Table 1. State wise maize cultivation statistics 2010-11

State	Area under hybrids (%)	Area under cultivation (mn hectare)	Yield (tones/hectare)
Karnataka	100	1.3	3.5
Rajasthan	25	1.1	1.8
Madhya Pradesh	16	0.8	1.2
Maharashtra	100	0.9	2.9
Andhra Pradesh	100	0.7	5.3
Uttar Pradesh	21	0.8	1.5
Bihar	80	0.6	2.2
Gujrat	21	0.5	1.6
Tamil Nadu	100	0.2	4.5
Others	60	1.5	2.1
All India	60	8.6	2.5

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

Almost all the districts of the north Ganga plain produce maize but the major production comes from Samastipur, Begusarai, Bhagalpur, Purnea, Purbi Champaran and Siwan districts. The hilly areas of Himachal Pradesh are also well suited to maize cultivation. Kangra, Mandi, Sirmaur and Chamba districts occupy an important position in the production of maize. Among the other producers are Jammu and Kashmir, Punjab, Orissa, Chhattisgarh and Jharkhand. In Punjab, cultivation of maize has given place to other kharif crops and its production has drastically fallen from 7 lakh tonnes in 1977-78 to 3.10 lakh tonnes in 2002-10. Still Jalandhar, Kapurthala, Rupnagar, Ludhiana, Amritsar, Faridkot and Patiala are important maize producing districts [24].

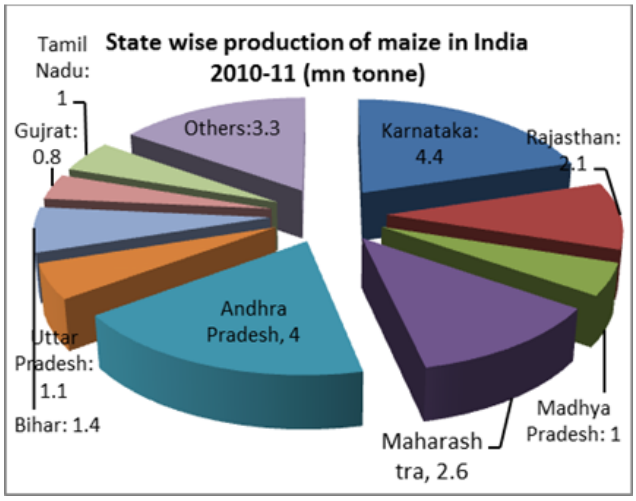

Figure 1.

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation

2. Taxonomy, Origin and Evolution of maize

Maize belongs to the tribe Maydeae of the grass family Poaceae. “Zea” was derived from an old Greek name for a food grass. The genus Zea consists of four species of which Zea mays L. is economically important. The other Zea sp., referred to as teosinte, is largely wild grass native to Mexico and Central America. The number of chromosomes in Zea mays is 2 n = 20.

Tribe Maydeae comprises seven genera which are recognized, namely Old and New World groups. Old World comprises Coix (2n = 10/20), Chionachne (2n = 20), Sclerachne (2n = 20), Trilobachne (2n = 20) and Polytoca (2n = 20), and New World group has Zea and Tripsacum. It is generally agreed that maize phylogeny was largely determined by the American genera Zea and Tripsacum, however it is accepted that the genus Coix contributed to the phylogenetic development of the species Zea mays. The individual maize grain is botanically a caryopsis, a dry fruit containing a single seed fused to the inner tissues of the fruit case. The seed contains two sister structures, a germ which includes the plumule and radical from which a new plant will develop, and an endosperm which will provide nutrients for that germinating seedling until the seedling establishes sufficient leaf area to become autotrophy. The germ is the source of maize “vegetable oil” (total oil content of maize grain is 4% by weight). The endosperm occupies about two thirds of a maize kernel’s volume and accounts for approximately 86 per cent of its dry weight. The maize endosperm is of various colors: blackish, bluish-gray, purple, green, red, white and yellow. When ground into flour, maize yields more flour with much less bran than wheat does. It lacks the protein gluten of wheat and, therefore, makes baked goods with poor rising capability. A genetic variant that accumulates more sugar and less starch in the ear is consumed as a vegetable and is called sweet corn. While yellow maize derive their color from lutein and zeaxanthin, in red-colored maizes, the kernel coloration is due to anthocyanins and phlobaphenes. [33]. These latter substances are synthesized in the flavonoids

synthetic pathway. Globally, it is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 per cent (782 mt) in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 35 per cent of the total production in the world and maize is the driver of the US economy. The USA has the highest productivity (> 9.6 t ha-1) which is double than the global average (4.92 t ha-1). Whereas, the average productivity in India is 2.43 t ha-1. Maize (Zea mays) belongs to the family of grasses (Poaceae). Maize cultivated globally and considered one of the most important cereal crops on the globe. The term "maize" is derived from the primeval word "mahiz" from the Taino language of the indigenous people of pre-Columbian America which is now an extinct language. It is believed maize was taken back to Europe by Columbus and other explorers with them and it spread across the business routes of Africa, Europe and Asia in the early 1500s and 1600s. When Europeans were familiarized to maize, they named maize as "corn," which was a general term for any grain at that time but has since then come to refer specifically to maize in the U.S. Today the terms maize and corn are often used interchangeably, with one being used more commonly than the other in certain regions or contexts, though in some European countries "corn" may also refer to wheat or barley.

3. Nutritional Significance of Maize

Maize as a crop is at par excellence for food, feed and industrial utilization however, it is deficient in essential amino acid, lysine and tryptophan. The composition of edible portion of maize (dry) is given in Table 2.

Table 2. Nutritional composition of maize

Calories	342.0	Calcium	10.0
Moisture (g)	14.9	Iron	2.3
Carbohydrates (g)	66.2	Potassium	286.0
Protein	11.1	Magnesium	139.0
Fat	3.6	Copper	0.14
Fibre	2.7	Amino Acids	1.78
Minerals	1.5	Riboflavin	0.10
Phosphorus	348.0	Thiamine	0.42
Sodium	15.9	Vitamin C	0.12
Sulphur	114.0	Carotene	90.0

Source: Gopalan et al., 2007[15]

3.1. Proteins of Maize

Several million people, particularly in the developing countries, derive their protein and calorie requirements from maize. With high content of carbohydrates, fats, proteins and some of important vitamins and minerals, maize acquired a well-deserved reputation as a poor man's nutria-cereal. Animal protein, of course being of higher quality, is scarce and expensive, thereby unavailable to a vast sector of the population. Therefore, this vast segment of human population depends upon cereals for their nutrition and livelihood. Protein from cereals including normal maize, have poor nutritional value because of reduced content of essential amino-acids such as lysine and tryptophan leading to harmful consequences such as growth retardation, protein energy mal-nutrition, anemia, pellagra, free radical damage etc. As a consequence, the use of maize as food is decreasing day by day among health conscious people [18].

Overall, proteins of maize, sorghum, millet, and rice are, in part, related and differ significantly from those of wheat, rye, barley, and oats. According to the amino acid composition they contain less glutamine and proline and more hydrophobic amino acids such as leucine. Maize storage proteins, called zeins, can be sub grouped into alcohol-soluble monomeric zeins and cross-linked zeins alcohol soluble only on heating or after reduction of disulfide bonds. With respect to different structures zeins have been divided into four different subclasses [28]. a – Zeins are the major subclass (791–85per cent of total zeins), followed by g - (10–20%), b - (1–5%) and d -zeins (1–5%), respectively. a -Zeins are monomeric proteins with apparent MW of 19,000 and 22,000 determined by SDS-PAGE. Their amino acid sequences contain up to ten tandem repeats [29]. Proteins of the other subclasses are cross-linked by disulfide bonds and their subunits have apparent MW of 18,000 and 27,000 (g -zein), 18,000 (b -zein), and 10,000 (d -zein).

Hybrid maize has specific features of having balanced amount of amino acids with high content of lysine and tryptophan and low content of leucine & isoleucine the balanced proportion of all these essential amino acid in quality protein maize enhances the biological value of protein. The biological value of protein in these is just double than that of normal maize protein which is very close to the milk protein as the biological value of milk and QPM proteins are 90 and 80 per cent respectively whereas it is less than 50 per cent in normal maize protein.

4. Malnutrition and Maize

Millions of people around the world suffer from 'Hidden Hunger or micronutrient deficiency. They do not get enough micronutrients required to lead healthy productive lives from the foods that they eat. The diets of poor people in developing countries usually consists of very high amounts of staple foods (such as wheat, rice and maize) but few micronutrient –rich foods such as fruits and vegetables and animal and fish products. The consequences of malnutrition are devastating and can result in blindness, stunting and even death. People across Asia depend on maize, rice and wheat but these staple crops do not meet daily dietary requirements and are deficient in essential vitamins (such as Vitamin A) and micronutrients such as iron and zinc. Nearly 200 million children, younger than five years, are undernourished for protein, which is a major national challenge. In this context, maize could play an important role worldwide [18]. Endowed with high content of carbohydrates, fats, proteins, some of the important vitamins and minerals, maize has acquired reputation of being poor man's nutritious food. Currently, utilization of maize as food crop is only 25 per cent, whereas its use for animal and poultry feed is almost 60 per cent. Another option is increasing area under hybrid varieties could lead to improved human nutrition and availability of low-cost

high quality feed for which internal demand is increasing at much faster pace. Also, transgenic varieties could be a cheaper source of protein for the children and thus can be used effectively as mid-day meal schemes.

Hybrid maize particularly QPM is an improved variety which contains higher amount of lysine and tryptophan with lower amount of leucine and isoleucine in the endosperm than those contained in normal maize. Such balanced combination of amino acids in the endosperm results into its higher biological value ensuring more availability of protein to human and animal than normal maize or even all cereals and pulses. As more than 85 per cent of the maize is used directly for food and feed, the quality has a great role for food and nutritional security in the country.

5. Benefits of Maize

The composition of maize endows it with many health benefits. The high fiber content prevents constipation and colorectal cancer. Antioxidants neutralize the effects of harmful free radicals that cause diseases like cancer. The antioxidant beta cryptoxanthin prevents lung cancer, while lutein prevents age related vision loss. Antioxidants slow cognitive decline and conditions like Alzheimer's. Vitamin C boosts immunity and fights infections, while the presence of vitamin E gives maize anti-aging properties [34].

Thiamine is required for boosting memory, cognitive functions and nerve health, and pantothenic acid is essential for energy, as it is linked to carbohydrate, protein and lipid metabolism. Folate is an essential requirement, especially during pregnancy. The phosphorus helps to maintain normal growth, kidney function and bone health. Magnesium boosts the latter, as well as regulates the heart rate. Finally, maize lowers LDL cholesterol and guards against cardiac diseases, diabetes and hypertension.

The traditional maize, like other cereals, also provides proteins, lipids and little water. Maize has also diuretic properties when taken as a tea and is a component in certain oils, corn oil and syrup. One of the nutritional benefits of maize comes from its rich carbohydrate that is derived from its abundant starch. Maize is also very rich in thiamine or vitamin B1, which is necessary for the brain to absorb glucose and to transform that food into energy. Biotin or Vitamin B7 give nutritional benefits to maize, since the deficiency of this vitamin in the body affects the state of the skin and hair. The nutritional benefits of maize are also determined by its vitamin A, which functions as an antioxidant in preventing diseases such as cancer. The high fiber content is another characteristic linked to the nutritional benefits of maize. This condition makes it suitable for diets that are made to lose weight and those made with the aim of lowering cholesterol levels. Anthocyanin is the name of the pigment that gives color to purple corn. Purple corn extract increases the activity of a gene that regulates the function of fat cells. Obesity and diabetes are the great evils of this new century and the properties of the purple corn then open new hope in preventing it.Purple corn extract or juice is a powerful antioxidant. This corn is also a good inhibitor of cholesterol and is a protector of the retina, stimulating blood circulation and prevents the development of colorectal cancer. Promotes tissue regeneration, prevents cardiovascular diseases, retards degenerative processes in general, has anti-wrinkle action, increases blood circulation, encourages diuretic action, so that in future instead of the harmful soft drinks, take purple corn juice.

6. More Health Benefits of Maize

6.1. Nutritious and Highly Appetizing

Maize flour is used to make nutritious bread which is highly palatable and is easily broken down in the body. When taken at intervals, bread helps to clean the colon and the dextrose produced is commonly used for medicinal purposes.

6.2. Prevents Constipation

Popcorn is a wholesome staple food made by heating small grains. It is easily digested by the body. In addition, it is practically starch-free, not fattening, and is converted into intermediate carbohydrates and dextrin, which is easily absorbed in the body. It promotes peristalsis and is also beneficial in preventing constipation.

6.3. Reduces Stomach Acidity

Maize facilitates the removal of toxic food substance and accelerates the passage of faeces through the intestine. Additionally, it protects the digestive tract thus promoting function of the gall-bladder and reducing stomach acidity.

6.4. Combats the Symptoms of Certain Cancers

Cereals generally wheat, rice, millet, oatmeal and maize should be eaten in large quantities since they are sources of carbohydrates and starch. Use of maize helps to combat the effects of certain cancers, as it reduces the development of cancer.

6.5. Reduce the Risk of Diabetes and Heart Diseases

Maize is low in cholesterol and fat content. Cereal or whole grains are great sources of vitamins and minerals, magnesium, fiber and complex carbohydrates. The fiber in whole grains helps to prevent the risk of heart diseases and diabetes, and all its nutrients boost the immune system. The main shortcoming is that most people are not aware of the numerous health benefits of maize, hence fail to include it in their nutrition.

7. Maize Side Effects

The major points against consumption of maize include a possibility of fungal and microbial infection and toxicity and skewed Omega 6: Omega 3 ratio. Besides these, some other concerns over consumption of maize happen to stem from the sugar and starch content of maize which gives this grain high calorific value which is not very good news for weight watchers. This concern also gives rise to a very serious question - is corn oil good for us or not. Considering the ubiquity of corn oil in just about every

processed and fried food and given its high trans-fat content, corn oil is not at all a good option for daily cooking purposes. If one is a discretionary snacker and binge on those fries not more twice or thrice a month, then it will not be very harmful for him. However, regular consumption should be avoided.

Canned sweet corn can be high in salt, with some brands containing as much as 545 mg of sodium per cup - close to a quarter of the recommended dietary allowance.

If any person is over 51years of age, are African American or have high blood pressure, diabetes or chronic kidney disease, the recommended amount is no more than 1,500 mg per day. One should then look for canned corn with no added salt where the sodium level drops to a modest 31 mg per cup.

Although maize is not fattening, it is a starchy vegetable, meaning it does contain carbohydrates. Consuming too many carbohydrates and overall calories can lead to weight and fat gain. If a person is overweight, the it is suggested to reduce daily calorie intake by 500 to 1,000 calories per day for a weight loss of one to two pounds per week.

Corn allergies are seen in adults as well as in children. When a person becomes allergic to corn, his body develops antibodies against corn proteins. Therefore, as soon as the person consumes corn products or even inhales corn particles or pollen, the immune system reacts against it, which gives rise to allergic reactions on the body. As corn is consumed by a large number of people, the number of corn allergy cases is increasing. Symptoms of corn allergy vary from very mild to severe ones. They are also found to differ from person to person. When a person is over sensitive to corn, consuming even a small quantity of corn can result in development of symptoms including vomiting, migraine headache, rash, abdominal pain and bloating, gas, nausea, itchy skin, swelling of tongue and mouth and fever. Anaphylaxis is the severest symptom of corn allergy. Although a rare condition, it can be life threatening. It can lead to impairment of several bodily functions. Anaphylaxis occurs unexpectedly and can be seen in children as well as adults. Research has shown that corn is harmless in those with diverticulitis. However, if one has diverticulitis and experience worsening of symptoms after eating corn, he should avoid it. Given both takes on the issue - is maize good? It can be determined that consumed in moderation and in its fresh form, maize is a great option for a healthy and tasty snack. As far as the concerns over corn allergy symptoms are concerned, let me tell you - it is extremely rare! Different people can be allergic to different things but that doesn't make that thing bad outright. We all know about people who are lactose intolerant but then the problem is not with milk, it is an issue with those people's systems which are unable to metabolize dairy. Given its high vitamin, phosphate and other nutrient contents despite the high fat and carbohydrate levels, if consumed once in a while and in moderation, maize does more good than harm.

Research have been done on utilizing maize with other traditional cereals and grains and been evaluated for the changes in physicochemical properties, nutritional value and organoleptic acceptability. Germination and soaking improved maize blended complementary porridges by reducing phytate (1739%) and tannin (2177%) contents and viscosity (2740%). All complementary porridges prepared in this study were accepted at laboratory (6.25 to 6.80) level using nine point hedonic scales and satisfied the minimum RDA for energy and protein and 2/3 of RDA for iron (7mg) and zinc (3mg) [35].

In another study at the scientists at Directorate of Maize Research, Cummings Laboratory,Indian Agricultural Research Institute, New Delhi, India prepared two types each of wheat flour and quality protein maize based biscuits and compared with standard wheat flour based biscuits. These biscuits were subjected for protein quality, in vitro protein digestibility (IVPD), shelf-life and organoleptic studies. Both protein quality and quantity improved in wheat flour and wheat flour + QPM based biscuits. Less increase in acid values and moisture contents were found to improve the shelf-life, which showed improvement in keeping quality under ambient conditions during 60 days of storage [36].

8. Commercialization of Maize Merchandise and Potential

In food enterprise, the simplest real increase is in niche meals markets, wherein manufacturers create value through adding unique offerings for clients, imparting great attributes like organic certification, specialized health products and so forth.

Consumers with special dietary needs for both specific health conditions and the general health concerns of our population particularly aging population offer more opportunities for creation of new products. For such people value added products of maize has great potential in the market and helped in creating production-consumption chain management for maize. Looking to the need and utilizing this opportunity by replacing or reducing, the use of traditional cereals and grains with maize may fulfill the gap between “what consumer needs” and “what is available in market.” For e.g. population suffering from celiac disease an incurable disease are bound to avoid all gluten containing food like wheat, rye and barley (which makes major portion of diet) and dietary modification is the only option. However, at the same time gluten, free foods are still difficult to find in market and if available, they are too expensive to fulfill daily dietary needs. Development, value addition, and commercialization of maize products may ensure better market availability of gluten free products at lower cost to the customer and big market opportunity to the food manufacturers.

Centre of Excellence on Maize Processing & Value Addition, MPUAT, Udaipur, Rajasthan, India has worked in this direction. Utilization of 100 per cent maize to different level of incorporation of maize in wide variety of products belonging to baked (cake, biscuit, cookies, muffins, bread etc.), extruded (puffballs, pastine), traditional food products (*Khaman*, *ladoo, mathri*, *bhujiya*, *shakkarpara* etc.) RTE and instant mixes (Cake mix, khaman mix, chapatti mix etc.) have been done using standard protocols. The developed maize products have been observed to offer acceptable sensory scores and improved nutritional profile to the consumers in terms of its protein, fiber, fat and mineral content. These products have been launched in local market and are found to be in most demand by the local population of the area. In

developing countries like India where half of the population still belongs to malnutrition, improving maize utilization with increased human consumption will help in ensuring nutritional security.

9. Way Forward

Several programmes are under implementation to reduce malnutrition through distribution of fruit & vegetable supplements rich in iron, zinc and vitamin A to target groups in the country. Though there are several food crops are available throughout the country maize serves to be a miracle crop of which nothing goes waste and on low cost serves to be nutritionally ideal. The promotion of maize through effective supply chain could help in reduction of malnutrition through following ways:

1. Improved participation of maize farmers in food processing and value addition chain management
2. Increased productivity of maize grains
3. Set-up of small scale enterprise in rural area generating employment and livelihood security
4. Employment generation for women and youth under production unit under advertising and marketing channels of maize.
5. Improved dietary safety and diversity in food choices to the consumers
6. Nutritional security due to increased intake of maize as food
7. Higher return to farmers due to higher yield hybrid varieties of maize over other cereals and 15-20 per cent incentive price for these varieties as compared to normal maize.
8. Motivation to big market players for adopting maize in food industries as an important grain.

The commercialization maize based food products depend at the output of FEIP (Farmer, Entrepreneur, group and people) chain. Maize is a crucial food and feed crop in lots of Asian, African and South-American international locations. Development and dissemination of appropriate maize composites and hybrids for one of kind places will cross a protracted manner for the food, feed and nutritional safety of the underprivileged population of those areas. The maize hybrid seed- industry play a widespread position in mitigating the necessities of hybrid seeds of maize. Consequently, there is need to involve private players for the seed production and link the enterprise with the farmers so that the farmers get an assured fair price for their produce. There is further scope to increase the lysine and tryptophan of maize, lysine being more than 5 per cent. There is need for a coalition for Sustainable nutritional security in developing countries with a vision to advocate policy and program decision that might improve nutritional security.

A huge segment of the population depends upon maize as a staple food. Recurrent food price crises, combined with the global financial, meltdown, volatile energy prices, natural resource depletion, and climate change are threatening to the livelihoods of millions of poor people. Together with rice and wheat, maize provides at least 30 per cent of the food calories of more than 4.5 billion people in 94 countries. They include 900 million poor consumers for whom maize is the preferred staple, 120-140 million poor farm families and about one third of all malnourished children. Between now and 2050, the demand for maize in the developing world will double, and by 2025 maize will have become the crop with the greatest production globally and in the developing world. Maize offers range of nutritional benefits and has clinical implications in various diseases. In India, most of the maize produced, used for animal feed and only a small portion utilized for human consumption, therefore its full potential is yet to be realized. Sustainable strategies to strengthen associations of maize product development with health and nutrition research as well as product delivery through marketing channels and thus maximize benefits to users and consumers is the need of the globe. Special emphasis on education about nutrition and cooking to optimize the impact of the bio fortified maize will improve the nutrition security. Maize offers great potential both for internal consumption as well as export in the region we need to harness this opportunity in global interest.

References

[1] Modi, A., "Amazing" 2014 Available http://www.businesstoday.in/magazine/features/cargill-india-ceo-siraz-chaudhury-maize/story/205721.html [Accessed August 28, 2016].

[2] CIMMYT, 2000. CGIAR Research, Areas of Research: Maize (Zea mays L.). 30 July, 2013. 04:48:38. [online] Available: http://maize.org/whymaize//. [Accessed June 2, 2016].

[3] AICRP. All India Coordination Research Project (AICRP) on Maize. 50th Annual Report by Directorate of Maize Research, Indian Council of Agriculture Research (ICAR). Pusa, New Delhi. 2007, 6.

[4] Tripathi, K. K., Warrier, R., Govila, O.P., Ahuja, V. "Biology of Zea mays (Maize)". Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. 2011. Available: http://www.envfor.nic.in/divisions/csurv/geac/Biology_of_Maize[1].pdf . [Accessed June18, 2016].

[5] Bressani, R.,. "Quality protein maize" In: Proceedings of the *International Symposium on Quality Protein Maize* (Eds Larkins, B. A. and Mertz, E.T.). EMBRAPA/ CNPMS, Sete Lagaos, Brazil, 41-63. 1995.

[6] Bressani, R, "Protein quality of high lysine maize for humans". *Cereal Foods World*, 36: 806-811.1991.

[7] CIMMYT "CGIAR Research, Areas of Research: Maize (Zea mays L.)" 4:48:38. 2000. Available: http://www.cgiar.org/areas/maize.htm.[Accessed June 10, 2016].

[8] Dado, R. G., "Nutritional benefits of specialty maize grain hybrids in dairy diets," *Journal. of Animal Science*, 77 (Suppl.2) /*Journal of. Dairy Science*, .82 (Suppl.2): 197-207. 1999.

[9] De Bosque, C., Castellanos, E. J. and Bressani, R., in INCAP Report Annual, INCAP, Gautemala, 75. 1988

[10] Narayan, S., Suchitra, M., and Sood J., "Maize Mania" *Down to Earth*, August 15, 2011. Available: http://www.downtoearth.org.in/coverage/maize-mania-33801. [Accessed June 20 , 2016].

[11] Dowswell, C.R., Paliwal, R.L. and Cantrell, R.P,. "Maize in the third world". In: Tripathi, K.K., Warrier, R., Govila, O.P., Ahuja, V. (2011). *Biology of Zea mays L. (Maize*). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India., 01-02. 1996.

[12] Morris, M. L. "Overview of the world maize economy". In: Tripathi, K.K., Warrier, R., Govila, O.P., Ahuja, V. *Biology of Zea mays (Maize*). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. 01-02. 2011.

[13] Agrawal, P.K. and Guptta, H.S., "Enhancement of Protein Quality of Maize Using Biotechnological Options". *Animal Nutrition and Feed Technology*, 79-91. 2010.

[14] Esen A and Stetler, D. A., "A proposed nomenclature for the alcohol-soluble proteins (zeins) of maize (zea-mays-". *Cereal Sci.,* (5) 117-128.1987.

[15] Food and Agriculture Organization of the United Nations (2012) FAOSTAT Database. http://faostat.fao.org/site/567/default.aspx#ancor [Accessed June 12, 2016].

[16] Galinat, W. C. "The origin of corn. Corn and corn improvement". *Agronomy Monographs*, 18: 1-31. 1988.

[17] Gopalan, C., Rama Sastri, B. V. and Balasubramanian, S. "Nutritive Value of Indian Foods" published by National Institute of Nutrition (NIN), ICMR. 2007.

[18] Graham, G.G., J. Lembake and E. Morales. "Quality-Protein maize as the sole source of dietary protein and fat in rapidly growing young children". *Pediatrics*, 85: 85-91. 1990.

[19] Graham, G.G., J. Lembake, E. Lancho and E. Morales. "Quality-protein maize: Digestibility and utilization by recovering malnourished infants". *Pediatrics*, 83: 416-421. 1989.

[20] John D. Floros, Rosetta Newsome, William Fisher Gustavo V. Barbosa-Canovas, Hongda Chen, C. Patrick Dunne, J. Bruce German, Richard L. Hall, Dennis R. Heldman, ´Mukund V. Karwe, Stephen J. Knabel, Theodore P. Labuza, Daryl B. Lund, Martina Newell-McGloughlin, James L. Robinson, Joseph G. Sebranek, Robert L. Shewfelt, William F. Tracy, Connie M. Weaver, and Gregory R. Ziegler. "Feeding the World Today and Tomorrow: The Importance of Food Science and Technology an IFT Scientific Review". *Comprehensive Reviews in Food Science and Food Safet*, 0: 1-28. 2010.

[21] Lodha, M. L., Srivastava KN,Gupta H.O, Mehta SL, Singh J. Nutritive value of normal and *oaque-2.Current Sci., 45: 286-286*. 1974.

[22] Maner, J. H. "High Quality Protein Maize". *In High Quality Maize* (ed. Drowden), Hutchinson and Ross, Stroudsburg, PA, 58-64. 1975.

[23] Mertz, E.T., Vernon, O. A., Bates, S., and Nelson, O.E. "Protein value of Colombian opaque-2 corn for young adult men". *Science*, 148:1741-1744. 1965.

[24] Mexico, D.F. "Maize seed industries revisited: emerging roles of the public and private sectors. *World Maize facts and trends*". CIMMYT. 1993/94.

[25] Mondal, P., "Maize Cultivation in India: Conditions, Production and Distribution" YourArticleLibrary.com, 2005 Available: http://www.yourarticlelibrary.com/cultivation/maize-cultivation-in-india-conditions-production-and-distribution/20918/. [Accessed June 1, 2016].

[26] Osei, S. A., Dei, H. K. and Tuah, A. K. "Evaluation of quality protein maize as a feed ingredient for layer pullet". *Journal of Animal. Feed Science*, 8: 181-189. 1999.

[27] Paes, M. C. D. and Bicudo, M. H. "Nutritional Perspectives of Quality Protein Maize". In: Larkins, B. A. and Mertz, E. T. (eds.). *Quality Protein Maize*: 1964-1994. *Proceedings* of the International Symposium on *Quality Protein Maize*. Sete Lagoas. pp. 65-78.1995

[28] Shaw, R. H. "Climate requirement". In: Tripathi, K. K., Warrier, R., Govila, O.P., Ahuja, V. (2011*). Biology of Zea mays (Maize).* Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. p. 01-02. 1988.

[29] Tatham AS, Mi fl in BJ, Shewry PR. "The b -turn conformation in wheat gluten proteins: relationship to gluten elasticity". *Cereal Chem* , 62: 405-412. 1985.

[30] Wilson CM. "Multiple zeins from maize endosperms characterized by reversed-phase HPLC". *Plant Physiol*, 95: 777-786. 1991.

[31] Zhai, Shao-Wei., "Nutritional evaluation and utilization of quality protein maize" Zhong Dan 9409 in laying hen feed. MSc Thesis, Shaanxi 712100, P. R. China, Northwestern Agricultural and Forestry University of Science and Technology, Shaanxi 712100, P. R. China. (M.Sc. thesis) 2002.

[32] Gao, Jun., Nutritional evaluation and utilization of quality protein maize Zhong Dan 9409 in pig feed. MSc Thesis, Chinese Academy of Agricultural Sciences, Beijing 100081, P. R. China. Chinese Academy of Agricultural Sciences. (M.Sc. thesis) 2002.

[33] https://en.wikipedia.org/wiki/Maize.

[34] Adom KK, Liu RH (2002) Antioxidant activity of grains. J Agri Food Chem 50:6182-6187. c.f. Health Foods: Concept, Technology & Scope by Gupta, R.K., Bansal, Sangita, Mangal, Manisha vol I pp. 294-295. Biotech publishing house, New Delhi.

[35] Beruk Berhanu Desalegn, Kebede Abegaz, Esayas Kinfe, Effect of Blending Ratio and Processing Technique on Physicochemical Composition, Functional Properties and Sensory Acceptability of Quality Protein Maize (QPM) Based Complementary Food, *International Journal of Food Science and Nutrition Engineering*, Vol. 5 No. 3, 2015, pp. 121129.

[36] Gupta HO and Singh NN, Preparation of wheat and quality protein maize based biscuits and their storage, protein quality and sensory evaluation, J Food Sci Technol, 2005, 42(1), 43-46.