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RESEARCH ARTICLE
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Maize diet and maize resistant starch in cardiovascular disorders

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ABSTRACT

Introduction: Corn, also known as maize, is a starchy grain that comes as kernels on a cob, covered by a husk. Although maize is yellow due to Carotenes, it has small amount of beta carotene. Carotenes help in preventing oxidative reactions and cancers. Rich in carbohydrates, maize provides minerals and vitamins like potassium, phosphorus, magnesium, iron and thiamine. A recent research at Cornell university indicates that cooking maize unleashes beneficial nutrients carotenoids that can substantially reduce the heart disease.

Conclusion: Maize is a healthy cereal, and widely consumed all over the world. Wheat can be replaced in North indian diets by maize, because of its nutritional composition and health benefits. Due to absence of gluten, it can be good cereal for celiac patients. High fiber content of maize makes it a magic cereal for hyperlipidemia and cardiovascular disease and diabetes mellitus. Maize resistant starch plays important role in reducing cholesterol levels and subsequently obesity related disorders.

Key Words : SFA (Saturated Fatty Acids), PUFA(Poly unsaturated fatty acids), MUFA (Monounsaturated fatty acids), RS (Resistant starch), phytochemicals, Anthocyanins, hyperlipidemia, cholesterol, insulin resistance, oxidative stress

INTRODUCTION

Corn, also known as maize, is a starchy grain that comes as kernels on a cob, covered by a husk. Farmers in southern Mexico first cultivated corn about 10,000 years ago from a wild grass called teosinte. Teosinte kernels were much smaller than modern maize kernels. Natives of North and South America grew Maize. Europeans who came to New England learned about it and brought it back to their home countries. The Pilgrims of Plymouth colony and members of the Wampanoag Tribe probably ate maize at the first Thanksgiving dinner in 1621. Maize / Corn has many nutritional benefits. Owing to its food value and numerous uses in the industry, corn is one of the most important crops in the world.

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Fig. 1 :

Nutritional Value of Maize:

Although maize is yellow due to carotene, it has small amounts of beta carotene. Carotenes help in preventing oxidative reactions and Cancers. Rich in carbohydrates, maize provides minerals and vitamins like potassium, phosphorus, magnesium, iron and thiamine. Maize oil contains 55% PUFA, 32% MUFA &12% SFA. Low amount of saturated fatty acids and good amounts of PUFA and MUFA makes maize oil heart friendly. Therefore,

Table 1 : Composition per 100 g of edible portion of maize	
Carbohydrate	71.88 g
Protein	8. 84 g
Fat	4.57 g
Fiber	2.15 g
Ash	2.33 g
Moisture	10.23 g
Phosphorus	348 mg
Sodium	15.9 mg
Sulfurr	114 mg
Riboflavin	0.10 mg
Amino acids	1.78 mg
Minerals	1.5 g
Calcium	10 mg
Iron	2.3 mg
Potassium	286 mg
Thiamine	0.42 mg
Vitamin C	0.12 mg
Magnesium	139 mg
Copper	0.14 mg

Source: Gopalan, Rama Sastri, and Balasubramanian (2007)

maize oil is good choice for heart patients. The proteins in maize are incomplete. They lack essential amino acids Lysin and threonine. Add pulses and legumes, nuts dairy products or animal protein, which contain the lacking amino acids of maize.(1)

A recent research at Cornell university indicates that cooking maize unleashes beneficial nutrients carotenoids that can substantially reduce the heart disease and cancer. Despite conventional Opinion that processing fruits and vegetables results in lower nutritional value than fresh produce, cooked corn retains its anti- oxidant activity even after the loss of vitamin C. In fact, cooking increases the antioxidants in maize by about 53 %. In addition to its antioxidant benefits cooked maize releases ferulic acid, a compound which provide many health benefits. These benefits are even more prounced in sweet corn. Ferulic acid is unique phyto- chemical found mostly in grains and in very low amounts in fruit and vegetables. It is found in very high levels in maize. Cooking maize increases the amount of ferulic acid significantly. Traditionally, Indian preparations use the entire grain for flat bread or chapati, roasted corn con, popcorn and most sweet corn preparations. The difference lies in the lack of dietary fiber in the refined form. Fiber is of two types: Soluble and insoluble. Soluble fiber known to lower cholesterol and blood glucose. The insoluble fiber is known to be beneficial for bowel function. Deficiency of dietary fiber has been linked to high cholesterol, cardiovascular disorders, diabetes and obesity. The glycemic index of maize is not very low(52), but its glycemic load is less, therefore it should be consumed in moderate amounts. Being gluten free, it is suitable for people with gluten intolerance or Celiac disease.

Don't let the the sweet taste of maize fool you. Choosing maize and whole grain maize products- rather than food that has processed white flour – can lead to better gut health and help lower your chances of getting diseases like cancer, heart disease, and type 2 diabetes mellitus. Some kind of gut bacteria may be part of the link cholesterol has to heart disease. When you eat foods like red meat or eggs, those bacteria make a chemical that your liver turns into something called TMAO (Trimethylamine –N – oxide). TMAO may help cholesterol building up in your blood vessels. Researchers are studying a natural substance called DMB (3,3 – dimethyl – 1-butanol) that's in Olive oil, corn oil and grape seed oil. They think it night keep your bacteria from making TMAO. Too much TMAO also may lead to chronic kidney disease. People who have the disease don't get rid of TMAO like they should. That surplus can lead to heart disease. Researchers think it is possible that too much TMAO might make you more likely to have chronic kidney disease in the first place (2).

The fiber in maize helps us stay full for longer between meals. It also increase healthy becteria in digestive tract, which may help protect against colon cancer and heart diseases.

Corn is rich in Vitamin C, an antioxidant that helps protect our cells from damage and wards off diseases like cancer and heart disease. Yellow maize is a good source of the carotenoids lutein and zeaxanthin, which are good for eye health and help prevent the lens damage that leads to cataracts. Blue and purple maize has more phytonutrients than white or yellow maize.

Recent studies reveals that Corn oil may help to reduce incidences of Ischaemic heart disease, though it requires more clinical studies to prove the point (3).

Zein an alcohol – soluble prolamine found in maize endosperm has unique novel applications in pharmaceutical and nutraceutical areas. Resistant starch from maize reduces

the risk of cecal cancer, atherosclerosis, and obesity related complications.

Health benefits of Maize:

Maize has various health benefits. The B complex vitamins in maize are good for skin, hair, heart, brain and proper digestion. They also prevent the symptoms of rheumatism because they are believed to improve the joint motility. The presence of vitamin A, C, and K together with beta carotene and selenium helps to improve the functioning of thyroid gland and immune system. Potassium is a major nutrient present in maize which has diuretic properties. Maize silk has many benefits associated with it. In many countries as India , china, spain, france and Greece it is used to treat kidney stones, urinary tract infections, jaundice, and fluid retention. It also has a potential to improve blood pressure, support liver functioning, and bile production. It acts as a good emollient for wounds, swelling, and ulcers. Decoction of silk, roots and leaves are used for bladder problems, nausea and vomiting, while decoction of con is used for stomach complaints.(13)

The presence of essential fatty acids, especially linoleic acid in maize oil plays an important role in the diet by maintaining blood pressure, regulating blood cholesterol level, and preventing cardiovascular maladies.(14,15,16) Moreover a tablespoon of maize oil satisfies the requirements for essential for essential fatty acids for a healthy child or adult.(17) Vitamin E in maize oil which is known as a key chain breaking antioxidant prevents the promulgation of oxidative stresses in biological membranes and prevents the development of atherosclerosis through intervention of maize oil in the diet.(18, 19)

Maize contains appreciable amounts of Anthocyanins. Anthocyanins have been well known for their health promoting benefits such as anti- Carcinogenic, anti- atherogenic, lipid lowering, anti- diabetic, antimicrobial, and anti – inflammatory properties. Due to the potent antioxidant properties they are able to decrease capillary permeability and fragility, immune system stimulation, and inhibit platelet aggregation (20). The dietary administration of purple maize pigment has been reported have anti-hypertensive effects on spontaneously hypertensive male rats through lowering the systolic blood pressure (21). The pigments from black glutinous maize cob have shown to possess potent anti- hyperlipidemic effects in high fat fed mice by improving the serum lipid profile and reducing the atherogenic index (22)

Resistant Starch:

Polysaccharides including resistant starch are categorized as dietary fiber and are used as an important prebiotic. Similar to soluble fibers, resistant starch also have a number of physiological effects that have been shown to be beneficial for health. Starch hydrolyzing enzymes, most importantly amylases, play essential role in production of resistant starch.

RS, by definition, is starch that reaches the large intestine in which it is fermented by bacteria. Therefore, RS is a type of fermentable fiber and could be considered 1 type of prebiotic, i.e., provides food for bacteria living in the large intestine.

Resistant starch from maize, also called as high amylose maize has various health beneficial effects. Maize endosperm contains 39.4 mg / 100 gm Resistant starch (4). It escape digestion and its consumption helps in altering microbial populations, lowering cholesterol and enhancing its fecal excretion, increasing the fermentation and short chain fatty acid production in small intestine, reducing symptoms of diarrhea, which altogether

reduce the risk of cecal cancer, atherosclerosis, and obesity related disorders (4). RS enhances the desirable composition of colonic bacteria in mice therefore might possess potential prebiotic properties (5). Its consumption influences cholesterol metabolism, lowers body fat storage therefore reduces the risk of atherosclerosis, hyperlipidemia, diabetes, and obesity (6). By definition, RS is any starch that is not digested in the small intestine but passes to the large bowel. Here, RS is a good substrate for fermentation which give rise to an increase in short chain fatty acid production. The differing rates of absorption between RS and digestible starch thought to denote their differential metabolic responses. RS intake is associated with several changes in metabolism which may conference some health benefits. RS intake seems to decrease postprandial glycemic and insulinemic responses ; lowers plasma cholesterol and triglyceride concentrations, improve whole body insulin senstivity, increase satiety, and reduce fat storage. These properties make RS an attractive dietary target for the prevention of diseases associated with , dyslipidemia and insulin resistance as well as the development of weight loss diets and dietary therapies for the treatment of Type 2 diabetes mellitus and coronary heart disease (6). Resistant starch can significantly shorten the intestinal transit time that leads to elimination of waste material through feces in a quicker time (7).

RS as dietary fiber helps in weight control as it reduces the food intake by diluting energy density of the diet as well as by modulating certain gene expressions (8). RS has also been suggested to be potentially beneficial for improving insulin sensitivity in both animal and human subjects (9).

The realization that low glycemic index diets were formulated using resistant starch led to more than a decade of research on the health effects of resistant starch. Federation of resistant starch in rodent studies results in what appeared to be a healthier gut, demonstrated by increased amounts of short chain fatty acids, an apparent positive change in the microbiota, and increased gene expression for gene products involved in normal healthy proliferation and apoptosis of potential cancer cells. Additionally, consumption of resistant starch was associated with reduced abdominal fat and improved insulin sensitivity. Increased serum glucagon like peptide 1 (GLP- 1) likely plays a role in promoting these benefits. In human subjects, insulin sensitivity is increased with the feeling of resistant starch. However, only 1 of several studies reports an increase in serum GLP – 1 associated with resistant starch added to the diet. This means that other mechanisms, such as increased intestinal gluconeogenesis or increased adiponect in, may be involved in the promotion of improved insulin sensitivity. Future research may confirm that there will be improved health if human individuals consume the requirement for dietary fiber and a large amount of the fiber is fermentable (10).

Boost fiber and resistant starch invisibly with High Maize Resistant Starch (Commercial product):

Consumers are looking to boost their fiber intake – they have heard the message loud and clear. Fiber is essential for health and well being. So they are looking for more fiber in everyday foods –but don't want to change the foods they love. Made from traditionally bred variety of maize, natural high maize RS invisibly adds fiber and resistant starch to a wide range of foods. More than 80 published clinical studies show the compelling health advantages

of natural high maize RS for digestive health, weight management, diabetes and energy management. Using high maize RS in foods or drinks opens new labelling opportunities too, with substantiated messages your customers are looking out for (11).

Maize diet and Oxidative Stress:

Postprandial hyperglycemia has been associated with increased oxidative stress and the development of diabetes , heart disease and all cause mortality. In 2013, A research article was published in Journal of the American college of Nutrition: Effect of Novel Maize based dietary fibers on Postprandial Glycemia and Insulinemia. The aim of this study was to assess the effect of novel maize based dietary fibers on postprandial glycemia and to assess the correlation between a rapid in vitro digestibility system and the blood glucose response. Clinical findings of this research revealed that Novel maize based dietary fibers all produce lower postprandial glycemic and insulinemic responses than the control. While further assessment is necessary in beverage and foods containing these fibers, they may be effective in applications for dietary strategies to control diabetes and other chronic diseases (12).

Table 2 : Concentration of major phytochemical compounds of maize per 100 gm

Compounds	Concentration (mg/100 gm)	References
(1) Caroteniods		
(a) Caratene	2.20	Waston and Ramstad (1987)
(b) Xanthophylls	2.07	Maros, Darnoko, Cheryan, Perkins, and
(i) Lutein	1. 50	Jerrell (2002)
(ii) Zeaxanthin	0.57	
(2) Phenolic compounds		
(a) Ferulic acid (FA)	174	Zhao et al. (2005)
(b) Anthocyanins	141.7	Salinas-Moreno, Soto-Hernandez, Martinez-Bustos, Ganzalez-Hernan-dez, and Ortega-Paczka (1999)
(3) Phytosterols	14.83	
(a) Sitosterol	9.91	
(b) Stigmasterol	1.52	
(c) Campesterol	3.40	

Phytosterols in Maize:

Maize contains appreciable amounts of Phytosterols. Dietary consumption of phytosterol is negatively related to cholesterol absorption, serum total cholesterol and LDL cholesterol (23). The major mechanism involved in the health benefits of dietary phytosterols is the inhibition of cholesterol absorption through intestine and stimulation of cholesterol synthesis resulting in the enhanced elimination of cholesterol in stools. To test the contribution of phytosterols in maize oil on cholesterol lowering effect, a study compared cholesterol absorption between the human subjects who consumed original and phytosterol removed commercial maize oil. The study reported that the cholesterol absorption of healthy subjects was 38% higher in the group consuming the phytosterol- removed commercial corn oil than

the group consuming the original commercial corn oil for two weeks. When corn oil phytosterol were added back to phytosterol- removed maize oil the cholesterol absorption was reduced significantly again. Thus the consumption of corn oil in a long term period can reduce cholesterol concentrations and prevent atherosclerotic disease (24).

Conclusion:

Maize is a healthy cereal, and widely consumed all over the world. Wheat can be replaced in North Indian diets by maize, because of its nutritional composition and health benefits. Due to absence of gluten ,it can be good cereal for celiac patients. High fiber content of maize makes it a magic cereal for hyperlipidemia and cardiovascular diseases &diabetes mellitus. Maize RESISTANT STARCH plays important role in reducing cholesterol levels and subsequently obesity related disorders. Maize contains appreciable amounts of nutrients (except low quality protein Zein, and niacin as bound form) , phytochemicals and physterols. These phytochemicals plays important role in the management of cardiovascular disorders. Based on the health benefits of maize discussed in this research paper, it can be recommended and made a part of our daily diet. Recent studies reveals that corn oil may help to reduce incidences of Ischaemic heart disease, though it requires more clinical studies to prove the point.

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