Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2023.49.007759

Now, We Need to Breed the Cereal Food Crop Varieties with Low Glycemic Index for 463 Millions Diabetic Population of the World

S G Borkar*

Soil, Seed, Plant Disease Diagnostic and Research Laboratory, Endeavour Scientific Agriculture, India

***Corresponding author:** S G Borkar, Soil, Seed, Plant Disease Diagnostic and Research Laboratory; Endeavour Scientific Agriculture, 103, Prestige Point, In Front of Nashik Road Police Station, Nashik, Maharashtra State, India

ARTICLE INFO

Received: February 11, 2023

Published: March 08, 2023

Citation: S G Borkar. Now, We Need to Breed the Cereal Food Crop Varieties with Low Glycemic Index for 463 Millions Diabetic Population of the World. Biomed J Sci & Tech Res 49(1)-2023. BJSTR. MS.ID.007759.

ABSTRACT

Diabetes Mellitus is a serious health issue in the world with around 463 million people suffering from this disease and 10 to 11 percent population of the most affected countries are diabetic. In countries like India, each year 1.5 million people are added to the category of diabetic people and such an increase should be a serious concern for the world health organization and the world community. Cereal food grains with high carbohydrates, high glycemic index, and high glycemic load are mainly responsible for this situation besides other factors. With the crop improvement programs in developed and developing countries like India, during the last century, the high-yielding carbohydrate-rich cereal crop varieties were developed to coup up with the food shortages and food nutrients, and coincidently during the same period, the percentage of diabetes Mellitus population steadily increased with around 80 million people as pre-diabetes and an estimated 77 million people (1 in 11 Indians) with diabetes in India, which makes India the second most affected country in the world, This is attributed to the change in lifestyle and food that we consume. Cereal food grains rich in carbohydrates are supposed to accelerate the glycemic index in the blood and the cereal food grain with high carbohydrates means food with a high glycemic load and thereby high glycemic index (sugar content) in the blood. As long as such high glycemic load food is made available to the diabetic population, their diabetic disease condition will not be cured. Therefore, we need to streamline the cereal crop varietal improvement program with proper carbohydrate and fiber content for millions of diabetic populations. This will also hold good for breeding other fruit crop varieties with a low glycemic load too for the present diabetic population and others on the borderline of diabetics. The paper discusses the present scenario of carbohydrates in cereal food crops and the expected carbohydrate content in these crops for the diabetic population. WHO and FAO of the United Nations with concerned International crop-specific research institutes like CIMMYT(for wheat and Maize), IRRI (for Rice), and ICRISAT (for Millets) should come forward for the supply of low carbohydrate-containing germplasm, landrace or wild derivatives of the concerned cereal crop to tackle this health issue for breeding low glycemic load crop varieties for the diabetic population of the world.

Keywords: Agriculture; Crop Varieties; Carbohydrates; Diabetes; Glycemic Load; Glycemic Index; WHO; FAO; CIMMYT; IRRI; ICRISAT

Introduction

According to the 2020 report of the International Diabetes Federation (IDF), 463 million people have diabetes in the world, out of which 88 million people belong to the Southeast Asia (SEA) region [1] and have the largest proportion of incident cases of type 1 diabetes in children of this region (Ramachandran, et al. [2]]). The prevalence of diabetes in the human population is 8.9%, according to the IDF, and further, as per estimates, India has the second highest number of children with type 1 diabetes after the United States. As per the World Health Organization, 2% of all deaths in India are due to diabetes [3]. Three countries of the world viz. China, India, and the USA have around 325 million diabetic people (Table 1 & Figure 1). In India, there are around 80 million people with the pre-diabetes condition and an estimated 77 million people (1 in 11 Indians) are formally diagnosed with diabetes [1], which makes India the second most affected country in the world, after China [3]. The number of people with diabetes in India has increased from 26 million in 1990 to 65 million in 2016 [4]. According to the 2019 National Diabetes and Diabetic Retinopathy Survey report released by the Ministry of Health and Family Welfare, the prevalence was found to be 11.8% in people over the age of 50 [5]. However, below the age of 50 years, the prevalence of diabetes is 6.5% and prediabetes is 5.7% among adults, according to the DHS survey (Chandrupatla, et al. [6]). The prevalence was similar in both male (12%) and female (11.7%) populations and was higher in urban areas. A high prevalence of diabetes is reported in economically and epidemiologically advanced states such as Tamil Nadu and Kerala (Tandon, et.al. [7]).

Table 1: Percent prevalence of diabetes in most diabetes countries.

	Population	Prevalence of Diabetes
China	1.39 billion	11.2 percent
India	1.33 billion	11.2 percent
United States	3.32 million	10.5 percent

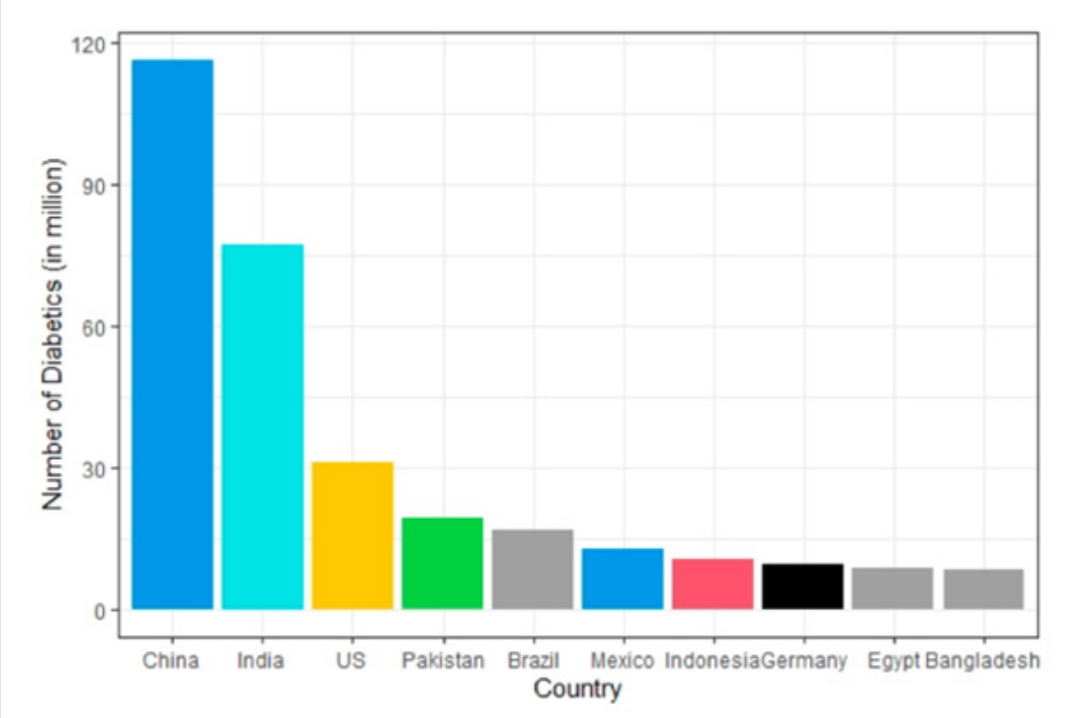

Figure 1: Countries with the highest number of diabetic patients worldwide in 2019.

Over the past three decades the burden of diabetes, in terms of deaths and Disability-adjusted life year (DALYs), has more than doubled in india. As per the Global Burden of Disease (GBD) Data Visualizations, the recorded death rate and DALY rate of diabetes in 2019 were 19.64 per 100,000 and 919.02 per 100,000 population, respectively, including males and females [8]. The GBD explore risk assessment framework estimated that diabetes-related DALYs are attributable to a high risk for Stroke, Coronary artery disease, Chronic obstructive pulmonary disease, Chronic kidney disease, Diarrhoeal diseases, Lower respiratory tract infection, Dietary iron deficiency, and Neonatal disorders. In india, type 1 diabetes is rarer than in western countries, and about 90 to 95% of indians who were diagnosed, had type 2 diabetes. A 2004 study suggests that the prevalence of type 2 diabetes in indians may be due to lifestyle changes resulting from

industrialization and migration to the urban environment from rural [9], and the change in food habits, particularly high carbohydrate-rich food. In 2020, Indians died of diabetes, hyperglycemia, kidney disease, or other complications like diabetic retinopathy due to diabetes are estimated to be 700,000. One in six people (17%) in the world with diabetes is from India and this number is projected to become 134 million by 2045 in India [4,10] indicating the seriousness of this disease and the steps to be taken for its minimization.

Scientific Facts

Diabetes Mellitus: Diabetic or Diabetes mellitus (DM) is a chronic condition or a disease that affects the body's ability to use the energy derived from food. It is the condition where the pancreas gland does not generate enough insulin required by the body to regulate glucose metabolism. During the digestion of the food, the stomach breaks down the carbohydrates and sugar to convert it into a special sugar called Glucose. This glucose is used to fuel up the body. But our body needs insulin, to convert this glucose into glycogen. However, in some people during glucose metabolism the body does not produce insulin, hence it leads to high blood sugar levels in the body which is called Diabetes Mellitus (Alam, et al. [11]). This condition is usually related to the pancreas, an organ that is involved in producing insulin. DM is primarily characterized by high blood glucose levels (hyperglycemia), polydipsia, and polyphagia. DM is one of the most common metabolic disorders that is increasing at an alarming rate all over the world [12]. The number of patients with DM has quadrupled (from 108 million in 1980 to 422 million in 2014) within 34 years only, while the worldwide incidence of diabetes among adults over 18 years of age has risen to 8.5% (2014) from 4.7% (1980) [12]. The WHO estimates that diabetes will be the 7th primary cause of fatality by 2030 [13]. There are mainly four common types of DM. Type 1 DM (T1DM) is caused by the autoimmune annihilation of the pancreatic-β cell with no insulin production [14]. This type is also called insulin-dependent diabetes mellitus (IDDM) [15]. This type of DM is seen in childhood and includes 5–10% of total diabetes patients [12]. The major type of diabetes is Type 2 DM (T2DM), which is caused due to insufficient production of insulin or desensitization of insulin receptors that precludes the entry of glucose into the cell [15,16]. The type is predominantly seen in 90–95% of cases.

Globally, the prevalence of DM has increased and therefore has grown in severity as a public health problem. Multiple risk factors are involved in the actual onset of the disease. Genetics, atmosphere, loss of very first phase associated with insulin launch, sedentary way of life, lack of physical exercise, smoking, alcoholic beverages, dyslipidemia, reduced β-cell sensitivity, hyperinsulinemia, improved glucagon activity are the primary risk elements for prediabetes and DM (Lee, et al. [17-19]). These factors appear to play a significant role in insulin resistance or insulin nonfunctionality resulting in disease advancement. Based on WHO [2011], approximately 90% of patients develop T2DM, mostly related to excess body weight. Obstructive sleep apnea and sleep disorder that are seen among overweight adult individuals are common risk factors for insulin resistance and glucose sensitivity which collectively progresses to prediabetes and then T2DM. The diet containing low fiber, but a high glycemic index (GI) is thought to be positively related to the onset of diabetes (Li, et al. [20,21]). There is evidence that free fatty acids are one important link between insulin resistance and T2DM. T2DM is also called as insulin resistance diabetes, where the pancreas's produce some insulin in the body, but the produced insulin is not sufficient as per the body's requirements for glucose metabolism or the cells are insensitive to the produced insulin to utilize the blood sugar. In normal blood sugar metabolism, insulin helps the cells to absorb the blood sugar. In an impaired blood sugar metabolism, the cells resist the insulin and cannot use the blood sugar and it continues to built up in the blood stream to cause Diabetic.

How Diabetic is Determined: Diabetic condition is determined by measuring the presence of sugar level or Glycemic Index in the blood. The glycemic index is a number from 0 to 100 assigned to a food, with pure glucose arbitrarily given the value of 100, which represents the relative rise in the blood glucose level two hours after consuming that food or in other words a figure representing the relative ability of a carbohydrate food to increase the level of glucose in the blood. A fasting blood sugar level of 99 mg/dL or lower is normal, 100 to 125 mg/dL indicates you have prediabetes, and 126 mg/dL or higher indicates you have diabetes. In term of glycemic index (GI), it is measured as: Low GI < 55, Medium GI (56-69) and High GI(>70).

Present Scenario of Carbohydrate Content in the Cereal Food Grain Varieties, A Main Contributor for High Glycemic Index to Cause Diabetes Mellitus: Food carbohydrates are the major sources of energy in the human diet [22]. These are primarily available in different cereal food crop as staple food and their quantity varies with the type of cereal (Table 2). Each food is assigning a glycemic index (GI) based on their blood glucose raising potential of the carbohydrate content of that food compared to a reference food (generally pure glucose). Carbohydrate-containing foods can be classified as high-GI (≥ 70), moderate-GI (56-69) or low-GI (≤ 55) relative to pure glucose (GI=100). Consumption of high- GI foods causes a sharp increase in postprandial blood glucose concentration that decline rapidly, whereas consumption of low-GI foods results in a lower blood glucose concentration that decline gradually.

What should be Tentative Carbohydrate Content of Cereal Crop to Manage Glycemic Load/Blood Sugar Level: To manage the glycemic load of the food, the carbohydrate content of the cereal /diet should be control. At present all the cereal crops and their varieties have the carbohydrate content in the range of 60 to 81 and the glycemic load/ meal of this food is in the range of 72-100 (Table 2) which has to be reduced to 11-19 (Table 3). To obtain this glycemic load, the percent carbohydrate content in cereal should be in the range of 8- 20, which will depend on type of cereal crop.

Table 2: Comparative Carbohydrate and Fiber content of different Cereal food grains/flour and their correlation with Glycemic load of the concern food meal.

Sr.No	Cereal Food	Carbohydrate Content (%)	Fiber Content (%)	Glycemic Index For Food crop	Carbohydrate taken/meal* (Av. Carb in gms/meal)	Glycemic Load for the Food
1.	Rice	76.5 – 81.1 (78.8)	0.2 – 0.9	64	118.2	75.64
2.	Wheat	61.3 – 73.6 (67.4)	2.7 – 10.7	69	134.8	93.01
3.	Maize	60.23 – 78.74 (69.4)	0.95 – 2.97	70	138.96	97.27
4.	Sorghum	72.1	6.7	70	144.2	100.94
5.	Pearl-millet	61.78 – 73.0 (67.3)	8.5	71	134.78	95.69
6.	Finger-millet	72.6	3.6	71	145.2	103.09
7.	Proso-millet	72.85	8.50	50	145.70	72.85
8.	Foxtail-millet	69.95	4.25	54	139.90	75.54

Note: *Rice/meal is taken @150gms while other cereal flour is taken@200gms.

Table 3: Suggestive carbohydrate content (%) of cereal crop for breeding these crops to manage diabetic condition of diabetes.

Sr.No	Cereal Crop	Present Glycemic index	Expected Glycemic load	Expected Av. carb/ meal	Expected Tentative Carbohydrate Content of Cereal (%)
1.	Rice	64	11-19	30	12.5 - 20
2.	Wheat	69	11-19	28	8 - 14
3.	Maize	70	11-19	28	8 - 14
4.	Sorghum	70	11-19	28	8 - 14
5.	Pearl-millet	71	11-19	28	8 - 14
6.	Finger-millet	71	11-19	28	8 - 14
7.	Proso-millet	50	11-19	38	11 - 19
8.	Foxtail-millet	54	11-19	36	10 - 18

Discussion

Cereals form the staple food of the people in most parts of the world, where these are grown and eaten, based on their cultivation in that geographical region. For example, in the areas where rice is grown, the people of that region mostly consume rice as their staple food. The people of the wheat producing region consume wheat and wheat products in their region and so on. The carbohydrate content of Rice [23], Wheat [24], Maize [25], Sorghum (Xiong, et.al. [26]), Pearl-millet [27], Finger-millet (Gull, et al. [28]), Proso-millet (Das et al. [29]), and Foxtail-millet [30] varies depending on the varieties of the particular crop and the crop growth environment (Giulia, et al. [31,32]). The carbohydrate content in the food is ultimately converted into the sugar which provide energy to the human organs and cells, during the glucose metabolism in the presence of insulin where this enters into the cells or remains in the blood in the increase form to cause a condition known as diabetes mellitus [33]. The food containing carbohydrates are denoted as the glycemic index for the food material which is used for determination of Glycemic load of that food [34] based on the quantity of carbohydrate of that food is consumed in a meal. Thus, Glycemic Load is an important yardstick to determine the suitability of the food for the diabetes mellitus patients.

Glycemic load (GL) estimates the impact of carbohydrate intake using the glycemic index (GI) while taking into account the amount of carbohydrates that are eaten in a serving. GL is a GI-weighted measure of carbohydrate content. For instance, watermelon has a high GI, but a typical serving of watermelon does not contain many carbohydrates, so the glycemic load of eating it is low. Whereas glycemic index is defined for each type of food, glycemic load can be calculated for any size serving of a food, an entire meal, or an entire day's meals. The glycemic load of a 100 g serving of food can be calculated as its carbohydrate content measured in grams (g), multiplied by the food's GI, and divided by 100. For example, A food with a GI of 90 and 8 g of available carbohydrates has a GL of 7.2 (8 × 90/100=7.2), while a food with a GI of just 6 and with 120 g of carbohydrate also has a GL of 7.2 (120 × 6/100=7.2). For one serving of a food, a GL greater than 20 is considered high, a GL of 11–19 is considered medium, and a GL of 10 or less is considered low. Foods that have a low GL in a typical serving size almost always have a low GI. Foods with an intermediate or high GL in a typical serving size range from a very low to very high GI.

Glycemic load appears to be a significant factor in dietary programs targeting metabolic syndrome, insulin resistance, and weight loss; and studies have shown that sustained spikes in blood sugar and insulin levels may lead to increased diabetes risk. The Shanghai Women's

Health Study concluded that women whose diets had the highest glycemic index were 21 percent more likely to develop type 2 diabetes than women whose diets had the lowest glycemic index (Villegas, et al. [35]). Similar findings were reported in the Black Women's Health Study (Krishnan, et al. [36]). Therefore, A diet program that manages the glycemic load aims to avoid sustained blood-sugar spikes and can help avoid onset of type 2 diabetes. Thus, for diabetics, glycemic load is a highly recommended tool for managing blood sugar.

A need to streamline the cereal crop varietal improvement program containing low carbohydrates for millions of diabetic populations:

In most of the developed and developing nations, the agriculture has changed during the last century by developing high yielding, fertilizer responsive, short duration crop varieties with higher nutritional quality. Indian agriculture has also come a long way from its food grain-deficient country after post-independence in 1950-60 to a food grain-self-sufficient country in 1970-80. This was mainly achieved through the green revolution and the dedicated work of an agricultural scientist in the country to develop high-yielding crop varieties to boost food production in the nation. The coordinated research projects on different crop varieties at the national level by Indian Council of Agriculture Research, State Agricultural Universities, and the agriculture department of the state, made it possible to boost food production. In this context, during the last 6 decades, the development of cereal crop varieties was mainly focused on their high yield-attributing characteristics, pest and disease resistance [37], besides the increase in carbohydrate, protein, other mineral content, and transfer of high yielding crop production technology [38].

Coincidently during the same period, the percentage of the diabetes Mellitus population is steadily increased in the country with around 80 million people as pre-diabetes and an estimated 77 million people (1 in 11 Indians) with diabetes, which makes India the second most affected country in the world, This is attributed to the change in lifestyle and food that we consume. Cereal food grains rich in carbohydrates are supposed to accelerate the glycemic index in the blood and the cereal food grain with high carbohydrates means food with a high glycemic load and thereby high glycemic index (sugar content) in the blood. As long as such high glycemic load food is made available to the diabetic population, their diabetic disease condition will not be cured. Therefore, to manage the glycemic load of the food, the carbohydrate content of the cereal /diet should be controlled. At present all the cereal crops and their varieties have the carbohydrate content in the range of 60 to 81 and the glycemic load/ meal of this food is in the range of 72-100 (Table 2) which has to be reduced to 11-19 (Table 3). To obtain this glycemic load, the percent carbohydrate content in cereal should be in the range of 8- 20, which will depend on the type of cereal crop.

This is only possible by developing the low carbohydrate (8- 20 percent) containing varieties of cereal crops. The study of (Marien, et al. [39]) showed that the yield and nutritional quality changes of cereal wheat grain occurred over the last 166 years (1850-2016), and further there was an increased in carbohydrate content with an impoverishment of mineral composition and protein content. The imbalances in carbohydrate/protein content was specially marked after 1960, coinciding with strong increases in ambient CO2 and temperature and the introduction of progressively shorter straw varieties. This is further evident form the reference of Das, et.al [29] that the reducing sugars originally present in 30 different varieties of indian wheat during that period were found to vary from 0.28 to 0.49 percent which has increased 4 times to a reducing sugar value of 0.97 percent during 2018 in the wheat varieties HD 4728 and UAS 448. In Indian agriculture, the breeding for high yielding and enhanced nutritional quality cereal started around the same period of 1960. The outcome of the program was marvelous with from grain deficient country to food garin surplus country. However, such cereal crop varieties happen to be with high carbohydrate content, which are responsible for the prevalence of diabetes in society. The increase in carbohydrate content in cereal, thereby increase in glycemic load and glycemic index of the cereal food is a cause of concern for the millions of people around the world.

This problem can be overcome if we start the cereal breeding program for the low carbohydrate contain varieties, at least for diabetes. For this purpose, the local land races or wild derivatives of these cereal crop material having low carbohydrate contain gene can be utilized in the breeding program. The cereal crop specific wild derivatives and land races accessions can be made available by the International Cereal Crop Research Institute viz. IRRI (for Rice), CIMMYT (for Wheat and Maize), and ICRISAT (for Millets). The FAO and WHO should work hand-in-hand in this program of developing low carbohydrate (8-20 percent) cereal varieities for 463 million diabetes of the world. At present, to manage the diabetic of 463 million population the medicine Metformin is used, which only regulates the blood sugar level, but do not cure the diabetic condition of the patient. Ghosal and Ghosal [40] indicated that Metformin can adversely affect renal functuions of T2DM patients and chronic kidney disease can develop. The serious side effect of lactic acidosis is rare but can develop because metformin can accumulate. Metformin should be used carefully in the elderly and in patients who have trauma, fever, surgery, heart failure, impaired kidney or liver functions. Treatment with metformin should be stopped before any type of surgery. The prolong use of this medication may have mild side effects particularly lactic acidosis and vitamin B12 deficiency (Sivadasan, et al. [41,42]). Therefore, there is an urgent need to streamline our cereal breeding programe for low carbohydrate varieties at national and internation level. When we are able to maintain our blood sugar with low carbohydrate cereal varieties as a staple food, the burden of taking Metformin can be overcome, and thereby its complications.

References

1. Kannan R (2019) India is home to 77 million diabetics, second highest in the world. The Hindu ISSN 0971-751X.

2. Ramachandran A, Snehalatha C, Ma R C W (2013) Diabetes in South-East Asia: An update. Diabetes Research and Clinical Practice 103(2): 231-237.
3. Anonymous (2020) Diabetes country profiles - World Health Organization. who int.
4. Atre S (2019) The burden of diabetes in India. Lancet Global Health 7(4): e418.
5. Sharma NC (2019) Government survey found 11.8% prevalence of diabetes in India. Livemint.
6. Chandrupatla S G, Khalid I, Muthuluri T, Dantala S, Tavares M, et al. (2020) Diabetes and prediabetes Prevalence Among Young and Middle-Aged Adults, And Geographic Differences In India- National Family Health Survey. Epidemiology and Health: e2020065.
7. Tandon N, Anjana R M, Mohan V, Kaur T, Afshin A, et al. (2018) The increasing burden of diabetes and variations among the states of India: The Global Burden of Disease Study 1990–2016. Lancet Global Health 6(12): e1352-e1362.
8. Anonymous (2021)"Institute for Health Metrics and Evaluation GBD compare data visualization". Healthdata org.
9. Mohan V (2004) Why are Indians more prone to Diabetes?. The Journal of the Association of Physicians of India 52: 468-474.
10. Atre S (2015) Addressing policy needs for prevention and control of type 2 diabetes in India. Perspectives in Public Health 135 (5): 257-263.
11. Alam S, Hasan MK, Neaz S, Hussain N, Hossain MF, et al. (2021) Diabetes Mellitus: Insight from Epidemiology, Biochemistry, Risk Factors, Diagnosis, Complications and Comprehensive Management. Diabetology 2(2): 36-50.
12. WHO (2017). WHO Global report on diabetes.
13. Mathers C D, Loncar D (2006) Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 3: e442.
14. Morran M P, Vonberg A, Khandra A, Pietropaolo M (2015) Immunogenetics of type 1 diabetes mellitus. Mol Asp Med 42: 42-60.
15. Tisch R, McDevitt H (1996) Insulin-dependent diabetes mellitus. Cell 85(3): 291-297.
16. Reinehr T (2013) Type 2 diabetes mellitus in children and adolescent. World J Diabetes 4(6): 270-281.
17. Reaven G M (1980) Insulin-dependent diabetes mellitus: Metabolic characteristics. Metabolism 29(5): 445-454.
18. Lee I M, Shiroma EJ, Lobelo F, Puska P, Blair SN, et al. (2012) Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. Lancet 380(9838): 219-229.
19. Knott C, Bell S, Britton A (2015) Alcohol consumption and risk of type 2 diabetes: A systemic review and dose-response meta-analysis of more than 1.9 million individuals from 38 observational studies. Diabetes Care 38(9): 1804-1812.
20. Li DW, Lu TF, Hua XW, Dai HJ, Cui XL, et al. (2015) Risk factor for new onset of diabetes mellitus after liver transplantation: A meta-analysia. World J Gastro enterol 21(20): 6329.
21. Sears B, Perry M (2015) The role of fatty acid in insulin resistance. Lipid Health Dis 14: 1-9.
22. Jequire E (1994) Carbohydrates as a source of energy. American J Clin Nutr 59(3 Suppl): 682S-685S.
23. Verma S, Srivastva S, Tiwari N (2015) Comparative study on nutritional and sensory quality of barnyard and Foxtail millet food products with traditional rice product. Journal of Food Science and Technology 52(8): 5147-5155.
24. Iqbal MJ, Shams N, Fatima K (2022) Nutritional quality of wheat. In(Edn.,), Wheat Intech Open.
25. Qamar S, Aslam M, Huyop F, Javed M A (2017) Comparative study for the determination of nutritional composition in commercial and non-commercial Maize flours. Pak J Bot 49(2): 519-523.
26. Xiong Y, Zhang P, Warner R D, Fang Z (2019) Sorghum Grain: From Genotype, Nutrition, and phenolic profile to its Health Benefits and Food Applications. Comprehensive Reviews in Foof Science and Food Safety 18(6): 2025-2046.
27. Malik S (2015) Pearlmillet- Nutritional value and medicinal uses. IJARIIE 1(3): 414-418.
28. Gull A, Jan R, Nayik GA, Prasad K, Kumar P, et al. (2014) Significance of fingermillet in nutrition, Health and value-added products: A Review. Journal of Environmental Sciences, Computer Science and Engineering & Technology 3(3): 1601-1608.
29. Das S, Khound R, Santra M, Santra D K (2019) Beyond Bird Feed: Proso millet for Human Health and Environment. Agriculture 9(3): 64.
30. Verma D K, Shukla K (2011) Nutritional value of Rice and their importance. Indian Farmers Digest 44(1): 21-23.
31. Dupont F M, Altenbach S B (2003) Molecular and Biochemical impacts of environmental factors on wheat grain development and protein synthesis. Journal of Cereal Science 38(2): 133-146.
32. Giulia S, Lea B F, Carol Z C, Lisa M, Harper S L, et al. 2020) The effect of climate factors on nutrients in Food: Evidence from a systematic map. Environmental Research Letters 15(11): 113002.
33. Ludwig DS, Hu F B, Tappy L, Miller JB (2018) Dietary carbohydrates: Role of quality and quantity in chronic disease. BMJ 361K 2340.
34. Thomas MS, Wolever D, Jenkin J A (1994) Glycaemic index of 102 complex carbodrate foods in patients with diabetes. Nutrition Research 14(5): 651-669.
35. Villegas R, Liu S, Gao YT, Yang G, Li H, et al. (2007) Prospective study of dietary carbohydrates, glycemic index, glycemic load, and incidence of type 2 diabetes mellitus in middle aged Chinese women. Arch Intern Med 167(21): 2310-2316.
36. Krishnan S, Rosenberg L, Singer M, Hu FB, Djousse L, et al. (2007) Glycemic index, glycemic load, and cereal fiber intake and risk of type 2 diabetes in US black women. Arch Intern Med 167(21): 2304- 2309.
37. Borkar S G, Patil B S (1995) Performance of Wheat Varieties for Leaf rust and Alternaria Blight Resistance. Indian J Of Mycology and Plant Pathology 25(3): 280-281.
38. Borkar SG, Kashid N V (2003) Frontline demonstration in Transfer of Technology in Wheat. SAIC Newsletter. 14(4): 8.
39. Mariem S, Gamez L, Larraya L, Teresa Fuertes-Mendizabal, Nuria Cañameras, et al. (2020) Assessing the evolution of wheat grain traits during the last 166 years using archived samples. Sci Rep 10: 21828.
40. Ghosal S, Ghosal S (2019) The side effects of Metformin – A Review.HSOA Journal of Diabetes & Metabolic Disorders 6: 030.
41. Sivadasan S, Subramanian M, Aiyalu R (2021) Metformin: Pros and Cons. In: J. Akhtar, U. Ahmad, B.badruddeen,and M.I.Khan (Eds.)., Metformin-Pharmacology and Drug Interaction. Intech Open.
42. Anonymous (2020) National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke. Directorate General of Health Services.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2023.49.007759

S G Borkar. Biomed J Sci & Tech Res

Submission Link: https://biomedres.us/submit-manuscript.php