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Whole grains and millets as raw ingredients for recipes in diabetes mellitus

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Abstract
The term diabetes mellitus was derived from the Greek words meaning passing through and sweet as honey (diabetes= flow through meh = honey). It is a chronic metabolic disorder with a strong hereditary basis, associated with high blood glucose. Basically it is caused by the deficient secretion of insulin by pancreatic cells. The two main types of diabetes classified by WHO are Insulin Dependent Diabetes Mellitus (IDDM) or Type 1 and Non- Insulin Dependent Diabetes Mellitus (NIDDM) or Type 2. About ninety per cent of diabetics belong to Type -2 (Raghuram, 1999).
Conventional treatment of diabetes mellitus is through insulin and oral glycemic drugs. However, this treatment may lead to micro- vascular and neurological complications. Insulin has also been reported to increase cholesterol synthesis and secretion of very low density lipoprotein which is not desirable for human health (Subbulakshmi and Naik. 2003).
Persons with diabetes mellitus follow a regulation of diet, as it is a sheet anchor of treatment and a useful supplement for insulin therapy in younger subjects. Several well – designed studies have shown that life style changes together with proper diet and physical exercise is essential to prevent Type- 2 Diabetes Mellitus (Yasumitsu *et al.,* 2002). Hence, in the earlier stages diabetes should not be neglected and proper diet therapy should be adopted (Dilawari *et al.,* 2004).

Keywords: Diabetes mellitus, IDDM, NIDDM

Introduction
According to diabetic principles of diet, enough calories are to be provided for maintaining ideal body weight (i.e. IBW) from complex carbohydrates, a diet high in protein for supplying amino acids for tissue repair and fat providing twenty per cent of calories should be consumed since fat cannot be oxidized as readily as carbohydrates. Therefore greater flexibility should be offered to the patient in choice of foods.

Whole grains
Cereal grains represent one of the world's major sources of food contributing up to 300 million tons annually. In particular, wheat is the major cereal produced and its grain products are highly consumed worldwide. Whole grains make up a significant group, which possesses great nutritional and bioactive properties due to its fractions, bran and germ, that comprise unique health-promoting bioactive components , presenting a more complex and beneficial nutritional profile than refined grains . These considerations have increased researchers' interest in exploring whole grain effects on human health and their bioactive fractions as potential sources for functional food and ingredients. Based on the World Health Organization report for 2012–2016, consumption of whole grains may decrease the risk of non-communicable diseases (e.g., type 2 diabetes, cardiovascular disease, hypertension and obesity), therefore a number of epidemiological studies, precisely large prospective studies that now include millions of person over years of follow-up, have underlined the inverse correlation between whole grain consumption, including the bran part, and the reduced risk of chronic diseases and metabolic syndromes. In addition, it was constantly reported that whole-grain foods had relevant biological activity in humans. This was as bran and aleurone are significant bioactive fractions, except when they are perceived as byproducts of the flour milling industry; therefore, being discarded and destined for animal feeding. Instead, they comprise most of the micronutrients, fiber, and phytochemicals of the grain that could significantly impact on the

nutritional quality of human food if integrated in flours or used as food ingredients . Emerging research suggests that phenolic acids may, together with fiber, be responsible for many of the health effects of whole grains and their derivatives account for about one-third of the total intake of polyphenols in our diet. Consumption of 2–3 servings per day (~48 g) of whole grains may reduce the risk of cardiovascular disease, cancer, and type 2 diabetes mellitus.

Health Benefits of Whole Wheat, Sorgum and Pearl Millet Grains

Scientific studies revealed that bran and germ fractions exhibit their positive health effects on both animal and humans by two mechanisms: First by releasing the indigestible fibers to modulate gut microbiota composition and activities; and second by delivering substrates, such as resistant starch, non-starch polysaccharides (β-glucan and arabinoxylans) and phenols to be metabolized into practical microbiota metabolites. The cereal bran is a major source of phenolic acids-antioxidants, fibers and minerals, whereas aleurone is the critical component generally overlooked in favor of indigestible fiber. Otherwise, it comprises the highest amount of bioactive compounds exhibiting significant antioxidant activity with ferulic acid as its major antioxidant. In cereals bran, besides being a cheap and readily available by-product of the cereal industry, its concentrated source of phenolic compounds have anti-inflammatory properties that can act beneficially on the gastrointestinal tract. The intake of whole grains may lower the incidence of colon cancer. Particularly, wheat bran is rich in phenolic acids, which are mainly covalently cross-linked with cell wall polymers. In order to exhibit their health related positive impact, phenolic acids have to resist food-processing conditions, be released from the food matrix, and be bio-accessible in the gastrointestinal tract, subject to metabolism, and reach the target. Therefore, the current trend on bioavailability and bio-accessibility, as well as valorization of waste compounds is becoming more and more popular.

Bioavailability of Nutrients

Bioavailability, from its nutritional side, refers to the efficient use of nutrients and bioactive compounds by the body, while bio-accessibility involves the released solubilized fraction into the gastrointestinal fluid that has become available for intestinal uptake.

Bioavailability is assessed by in vivo studies of blood and/or urine metabolites after consumption of targeted compounds, while bio-accessibility is determined by in vitro studies that analyze the amount of compounds available for intestinal uptake. Researchers are searching for strategies and processing technologies to enhance the content and bioavailability of nutrients and bioactive compounds of cereal foods. The bioavailability of compounds depends on inaccessibility, absorption, transformation, disposition and excretion, where the main issue is inaccessibility, which is affected by how food processing influences nutrients available for digestion and absorption in the gastro- intestinal tract. In order to validate phenolic acids bioactive potential in humans and their dietary importance in already processed food, an assessment of their changes during processing is also necessary. Based on the recent findings on the health related effects of bran components, the approach of using it as a functional food ingredient in bakery and pasta processes is of major interest, as well are the strategies to increase their phenolic acids inaccessibility or bioavailability.

However various studies focused on works assessing inaccessibility and bioavailability, food processing influence and recent strategies and technologies to unlock phenolic compounds inaccessibility and bioavailability. Finally, this work is intended to encourage new research in an area with promising findings in the near future.

Wheat, rye, rice, oats or barley are among the major whole grains representing a major source of food for humans since old times. All these grains are structurally similar and divided into three distinct fractions: The outer fiber-rich bran, the micronutrient-rich germ and the starchy main 'body'.

After food processing, the kernel has to keep the same ratio of bran, germ and endosperm as the original grain in order to be declared as "whole grain". In 2006, the United States (US) Food and Drug Administration (FDA) approved the whole grain label, but currently each country or responsible association/organization is updating their definition for whole grain and whole-wheat products, as they are different. There is a strong need for a general approved definition of whole grain and whole-grain foods, as well as knowledge on their health related-compounds in food and their positive impact after intake.

The content of phenolic compounds is actually 15- to 18 fold higher in bran than that of the endosperm, which contains only 17% from the total phenolic content. The bran coatings are as-follows: The bran is the outer skin composed of multiple layers, which contains fiber, minerals, vitamins and bioactive compounds, among which phenolic acids are of interest being classified as bioactive phytochemicals that have important health effects on humans. The germ is the embryo, which contains essential fatty acids, B vitamins, vitamin E, selenium, and antioxidants. The endosperm, having the largest size of the kernel, comprises mostly starchy carbohydrates, like glucose. The amount of nutrients and bioactive compounds is strongly influenced by grains species, the cultivar used, and the growing conditions.

The percentage extraction of flour is the extraction rate, which is defined as the proportion of extracted flour with respect to the initial weight. The white flour is obtained for extraction rates equal or lower than seventy fiver per cent.

The significant bioactive compounds in whole-grain cereals are phenolic compounds among which ferulic acid and cinnamic acid are representative; dietary fibers, like beta-glucan; lignans, phytic acid, inositols and betaine.

The structures of the whole-wheat grain, bran and aleurone layer, and their main dietary fibers arabinoxylan together with arabinoxylan oligosaccharides (AXOS), and phenolic acid ferulic acid components. From macro to molecular levels, the most nutritionally interesting technological fractions of wheat bran and aleurone layer, as well as arabinoxylan and ferulic acid components. The phenolic compounds are found under glycosides forms linked to different sugar moieties, or as other forms linked to organic acids, amines, lipids, carbohydrates and other phenols, whereas the major ones are phenolic acids. Phenolic acids are among the majority metabolites of cereal crops with antioxidant effects on humans and they are of a major importance as they represent 30% of total phenolic acids in Mediterranean diets. Phenolic acids are a specific class of polyphenols which are usually involved in mechanisms of defense against biotic and abiotic stresses. The phenylalanine serves as the substrate for the initiation of phenolic acids biosynthesis via the phenyl propanoid pathway.

The biotic and abiotic factors, like environmental issues and agronomic strategies, can influence the biosynthetic pathway, therefore the phenolic acid content may vary. Additionally, the genetic influence must be considered, as the genetic-environmental interactions may result in a large phenolic content fluctuation among cereal species and cultivars of the same species. The phenolic acids occur in free, conjugated or insoluble bound forms, whereas about 95% of grain phenolic compounds (PC) are ester-or ether-linked to cell wall polysaccharides and crosslink them intra- and/or intermolecular to form networks. They are also indicated as dietary fiber and phenolic compounds (DF-PC). The whole grains phenolic acids are divided into hydroxybenzoic acids and hydroxycinnamic acids, based on C1–C6 and C3–C6 skeletons, respectively. The hydroxybenzoic acid derivatives comprise p-hydroxybenzoic, vannilic, syringic, and gallic acids while the hydroxycinnamic acids include ρ-coumaric, caffeic, ferulic, and sinapic and occur in the form of esters and glycosides. Ferulic acid is the major hydroxycinnamic acid. The other derivates, as well asbenzoic acid derivatives, occur in smaller amounts.The World Health Organization estimates that approximately one-third of worldwide infant deaths and one half in developing countries can be attributed to malnutrition. More specifically, iron (Fe) deficiency is the most common nutritional deficiency worldwide.

Iron (Fe) deficiency in India report 79% of pre-school children and 56% of women to be anemic. Fe supplementation program in India since 1970 failed to address the issue of iron deficiency. Iron deficiency is particularly widespread in low-income countries because of a general lack of consumption of animal products (which can promote non-heme iron absorption and contain highly bioavailable haeme Fe) coupled with a high consumption of cereal grains and legumes replete with anti nutrients (e.g., polyphenolic compounds and phytic acid) that are inhibitors of iron bioavailability.

Poor dietary quality is more often characterized by micronutrient deficiencies or reduced mineral bioavailability, than by insufficient energy intake. Diets with chronically poor iron bioavailability which result in high prevalence of iron deficiency and anemia increase the risk of all-cause child mortalities and also may lead to many patho physiological consequences including stunted growth, low birth weight, delayed mental development and motor functioning, and others. Thus, a crucial step in alleviating Fe deficiency anemia is through understanding how specific dietary practices and components contribute to the iron status in a particular region where-iron-deficiency-is-prevalent.

Pearl Millet

Pearl millet is a resilient cereal crop, grown mostly in marginal environments in the arid.

It is a major dietary constituent for peoples living in Western India and the Sahel region of the African continent, and is often served as a complementary food for infants and young children. For instance, among the rural poor in India, pearl millet intake can reach nearly 60% of all cereal grain consumption and semi-arid tropical regions of Asia and Africa.

A major non-nutritional advantage to PM consumption is that it can be grown in areas with very limited rainfall, where crops such as maize or sorghum are very likely to fail during most-growing-seasons. As a well-adapted crop to growing areas characterized by drought, low soil fertility, and high temperature, it performs well in soils with high salinity or low pH. With regard to nutritional quality, PM is at least equivalent to maize and generally superior to sorghum in protein content/quality and metabolized energy levels as well as digestibility. Furthermore, PM does not usually contain significant amounts of condensed polyphenols, such as the tannins commonly found in other staple crops such as sorghum, which can decrease digestibility. Bajra grains are also rich in important micronutrients such as iron and zinc coupled with a complete amino acid family in comparison to sorghum and-maize. With a holistic approach, these qualities make bajra grains a major contributor of dietary protein, zinc and iron. It is consumed by in different clans of population in both in India. Recently, conventional plant breeding at ICRISAT (International Crops Research Institute For the Semi-Arid Tropics, Andhra Pradesh, India) has developed bio fortified pearl millet containing up to 90 µg iron/g, a substantial increase over standard pearl millet containing-36-50 µg-iron/g.

Pearl millet is an important source of dietary energy, and provides nutritional security for people in the third world countries, particularly in Africa and Asia. Previous studies have shown that pearl millet is an excellent source of micronutrients like iron and zinc. Owing to the presence of inhibitors like phytic acid, polyphenols, and fibres, the bioaccessibility of iron and zinc is very low in pearl millet diet. The present review is an attempt to highlight the localisation of minerals, phytic acid, and polyphenols in pearl millet grains, and various strategies that are being employed for the reduction of inhibitory factors. This review also appraises and gives an overview of the application of combinations of processing conditions and enhancers, that increases the bioavailability of iron and zinc either by way of reduction of inhibitory factors or prevention of binding of these inhibitory factors to minerals. The above strategies could be employed to provide better insights into the relevance of different processing methods, to help in the development of foods with-enhanced-mineral-bioavailability.

Pearl millet (*Pennisetum glaucum*), a descendent of the wild West African grass and domesticated in the Saharan Desert, spread to East Africa and then to India. Presently, pearl millet is one of the most important cereal crops, grown in the tropics and ranks third in sub-Saharan Africa (Nigeria, Niger, Burkina Faso, Chad, Mali, Mauritania and Senegal in the west, Sudan and Uganda in the east). India's contribution to pearl millet production accounts for 44% of the world millet production (FAO 2016) [6]. In the third world countries, millions of people still depend on pearl millet to sustain their livelihood. Pearl millet is consumed in the form of large balls rolled from flour, parboiled grains, or fermented beverage. In northern Nigeria and southern Niger, this beverage is a popular drink called "fura" (Asp, 1994) [1]. It is an under-utilised crop, however, its immense nutritional potential has not been tapped. In comparison to maize or wheat that are un cultivatable in harsh conditions, pearl millet is cultivatable in areas with drought, low soil fertility, high salinity, low pH or high temperature. Even in case of climate change with harsh temperature conditions, pearl millet is adaptable. It had also been reported that as compared to other cereals pearl millet showed greater ceiling temperatures for grain yield, making it a climate resilient crop suitable for semi-arid regions of the world. Since pearl millet is almost free from major diseases and insect attack, it could be cultivated with good harvest.

Nutrition plays a significant role in controlling communicable and non-communicable diseases in humans. Malnutrition, the worst form of the non-communicable disease, is an important risk factor, for emerging chronic diseases at a later date. Malnutrition occurs mainly in children consequent to the inadequate supply of the recommended dietary allowance (RDA). The RDA is the amount of nutrients required to prevent diseases. A study has shown that more than 70% of pre-school children consume less than 50% RDA of iron, vitamin A and riboflavin (Aune *et al.*, 2016) [2]. Pearl millet is a rich source of many health-related components such as iron, zinc, folic acid and β-carotene could be used for combating malnutrition arising out of deficiency of minerals. To enhance iron and zinc bioaccessibility in pearl millet, a proper understanding of the effect of various processing technologies on the reduction of inhibitory factors is required. The above strategy could help in addressing the issue of micronutrient deficiency to a great extent.

Pearl millet grain is encased in a tough fibrous seed coat rich in inhibitory factors like phytic acid, and polyphenols that readily form complexes with dietary minerals, such as calcium, zinc, and iron leading to a marked reduction in their bioaccessibility and bioavailability. These factors affect the nutritional potential of grains.

The phytic acid (inositol hexakisphosphate) content of cereals varies from 0.5 to 2 g/100 g. In particular, whole grain cereals have a high content of phytic acid. Phytic acid forms complex with minerals (such as iron, zinc and calcium), and becomes insoluble at the physiological pH of the intestine. Hence it reduces the uptake of the above essential dietary minerals in the human gut. In humans, inhibition of iron, zinc and calcium absorption by phytic acid is dose-dependent. Inositol tri and tetraphosphate contributed to low absorption of iron in processed food containing a mixture of inositol phosphates, which could probably due to the interaction of iron with higher phosphorylated inositol phosphates. The Indian pearl millet cultivars contain phytic acid in the range of 0.713–0.726 g/100 g. Jha *et al.* (2015) reported that pearl millet bran fractions contained high phytic acid (1.02 g/100 g) than the endosperm fraction (0.56 g/100 g).

During the process of cereal grain germination, the extractability of divalent cations enhanced due to the diminishing of phytic acid by the hydrolytic activity of native phytases. The action of microflora during fermentation also enhanced the extractability of minerals and reduced the phytic acid content, through the hydrolysis of the phytate–mineral complexes, this resulted in elevated extractability of the fermented product by releasing the divalent cations in free form.

The phytic acid content is less in the endosperm as compared to the aleurone layer. A fivefold increase in the absorption of minerals was noticed upon complete degradation of phytic acid; however, a 90% degradation (1–0.1%) caused a twofold increase in absorption, this suggests that complete degradation of phytic acid might not always be possible. Therefore, to achieve a twofold increase in iron absorption from an iron-fortified complementary food. The molar ratio of phytic acid to iron should be reduced to < 1 or preferably < 0.5 from its native level, since the complete destruction of phytic acid is not always possible.

The polyphenols in pearl millet occur in the range of 307–714 mg/100 g. It is the bran fraction of pearl millet that contained a high amount of polyphenols (1.44 g/100 g) when compared to the endosperm (0.45 g/100 g) fraction. Certain polyphenols formed a complex with iron, making complex-bound iron unavailable for absorption. The amount of iron-binding phenolic galloyl groups in foods roughly corresponds to the degree of inhibition of iron absorption. The above workers also reported that the major inhibitory effect on iron absorption was due to iron-binding galloyl groups rather than phenolic catechol groups that affected iron absorption to a minor extent. Most food polyphenols could actively inhibit dietary non-haem iron absorption. Hence, correlation of iron bioaccessibility with the particular phenolic group instead of total polyphenol content appears to be more appropriate. In pearl millet, information is limited on the different types of phenolic compound that inhibited iron absorption.

Cereals also contain polysaccharides other than starch, called the non-starch polysaccharides. In cereals and millets, the non-starch polysaccharides are the primary source of both soluble and insoluble dietary fibres. Pearl millet contains 5 g/100 g of insoluble and 3 g/100 g soluble dietary fibres Insoluble complexes with divalent cations such as iron and zinc, hindering their absorption in the intestine. The fibres together with phytates chelate minerals and form fibre–phytate–mineral complexes. The process of germination is shown to increase the soluble fibre and decrease insoluble fibre content in pearl millet. It had been reported insoluble (63.52 g/100 g) and soluble (1.63 g/100 g) dietary fibre in bran fraction as well as in endosperm fraction (5.47 and 1.36 g/100 g, respectively). A study on cereals and pulses revealed that both soluble and insoluble dietary fibres affected zinc bioaccessibility in cereals, while in pulses only insoluble fibres showed the negative effect. Pearl millet caryopsis is comprised of the outer pericarp, aleurone, germ and starchy endosperm (Fig. 2). The pattern of distribution of primary storage components such as proteins, iron, zinc, phytic acid and polyphenols could be histochemically localised; this helps in the proper understanding of the localisation of inhibitory factors in the grain. In wheat, millet, barley, and rice, phytic acid is found localised in the aleurone layer, while in corn, a majority (80%) of it is concentrated in the germ region. Iron was in the peripheral than in the endosperm regions of pearl millet.X-ray fluorescence imaging revealed that in case of rice, zinc is found abundantly located in the embryo and aleurone layer. The localisation of ferric and ferrous forms of iron in rice grains was also studied. Another study by Micro-PIXE mapping on pearl millet mineral distribution revealed that minerals are localised within the germ. However, studies detected iron and zinc in pearl millet flour using Perl's Prussian blue and Dithizone staining techniques.

The amount of micronutrients that remain in grains as well as their bioaccessibility after standard processing in the regular daily diet determines the micronutrient status in staple food crops. The bioavailability of a nutrient is defined as the proportion of the ingested micronutrient that is absorbed and used for normal body functions (Awika *et al.*, 2003) [4]. Iron and zinc content varies depending on the cultivar and grain fraction. Anderson and Hanna, 1999 [7] reported iron and zinc contents in pearl millet cultivars in the range of 42–79.9 and 27.2–50.2 mg/kg, respectively. Antony *et al.*, 1996 [8] reported iron and zinc content of 25.71 and 6.56 mg/100 g in bran and 12.74 and 6.07 mg/100 g in the endosperm, respectively. Improved iron absorption with the phytate-to-iron ratio of < 1:1 and preferably < 0.4:1 in plain cereal and legume-based meals, or < 6:1 in composite meals including vegetables with added enhancers like ascorbic acid and meat. In case of zinc, its absorption in a diet based on unrefined cereals was estimated at 18–28% when the phytate/zinc ratio was > 18. Further, for phytate/zinc ratio between 4 and 18, the absorption rate was 26–34% (Brown, 2011) [5]. The domestic grain processes such as germination, fermentation, or hand pounding of African cultivars of pearl millet resulted in mineral extractability ranging widely between 23 and 70% reported that the iron content in whole grain, bran and endosperm fractions of pearl millet were 5–6.4, 3.1–4.7 and 4.1–5.8 mg/100 g, respectively and the bioaccessible iron content in the above fractions were 0.16–0.44, 0.16–0.20 and 0.20–0.48 mg/100 g, 0.11 and 0.10 mg/100 g bioaccessible iron in bran and endosperm while the bioaccessible zinc was 1.01 and 0.94 mg/100 g, respectively. Four isocaloric diets differing in the type of cereal, i.e. pearl millet, sorghum, wheat or rice. The bioaccessibility of iron and zinc in the natural diets significantly improved upon the substitution of pearl millet diet, particularly when the micronutrient-rich commodities like vegetables is low in the diet. Another study revealed that feeding of young children with biofortified iron and zinc in pearl millet as a major food, fulfilled the dietary requirement for these micronutrients. The treatment of pearl millet flour with endogenous and exogenous phytases enhanced the iron and zinc bioaccessibility, which was attributable to the degradation of phytic acid. Simple processing procedures like soaking, germination or fermentation enhanced mineral bioaccessibility in case of rice and other cereals, due to reduction in phytic acid content. Several traditional food-processing and preparation methods are available at the household level that enhance of the bioaccessibility of micronutrients in cereal-based diets. The methods include soaking, blanching, decortication, hydrothermal processing, germination, acid treatment, or fermentation, or combination of treatments and incorporation of enhancers. The soaking of grains reduces phytic acid content which might depend on the species, pH, and conditions and duration of soaking. It had been reported that 15% reduction in polyphenols upon soaking of pearl millet for 14 h. Soaking decreases the phytic acid and polyphenol contents from 10–41 and 11–15%, respectively (Tables 3, ,4).4). Soaking of bran and endosperm fractions in water resulted in the reduction of polyphenols (1 and 4%) and phytic acid (41 and 52%). Soaking of cereal and most legume flour in water resulted in the passive diffusion of water-soluble Na, K, or Mg phytates. A reduction in iron and zinc contents following soaking of whole grains of millet, maize, sorghum, rice, soybean, cowpea, and mung bean, which was attributed to leaching of minerals in soak water. Soaking of sorghum flour at room temperature for 24 h caused 16–21% reduction in phytic acid content. Soaking grains in acidic and alkaline solution has been found to affect inhibitory factors and also mineral bioaccessibility. Grain soaking for short duration in acidic or alkaline medium resulted in a decrease in the inhibitory factors without loss in minerals. The alkaline soaking reduced flavonoids by 62.7% in the endosperm rich fraction while acidic soaking of bran rich fraction reduced the phytic acid to the maximum extent. This process improved the zinc bioaccessibility by 35% in the bran rich fraction and iron bioaccessibility by 2.5% in endosperm fraction. Reports in pearl millet indicated that acid treatment reduced phytic acid by 77–82%.

Blanching is a process in which grains are submerged in boiling water at 98 °C (1:5, grain to water) for 30 min, followed by drying for 60 min at 50 °C. It is by blanching, that could reduce inhibitory factors, rancidity, and bitterness in biscuits prepared from pearl millet (Chobanian *et al.*, 2003) [3] reported that blanching of pearl millet was an effective method for reducing inhibitory factors. The blanching of pearl millet was found to reduce phytic acid and polyphenol contents from 34–39 and 14– 29%, respectively. Studies demonstrated that hydrothermal treatment of finger millet resulted in the reduction of phytic acid and polyphenol contents, which in turn, increased the iron and zinc bioaccessibility. Phytic acid degradation by hydrothermal treatment mainly depended on the-temperature-pH-and-plant-species. The mechanical method involving household pounding of cereals separates the pericarp from germ which in turn removes the phytic acid besides some minerals and vitamins, but the process might enhance bioaccessibility of minerals. Most developed countries, therefore compensate for the micronutrients lost in milled cereal flours by mineral enrichment. Decortication, one of the first steps in the preparation of traditional cereal-based dishes in West Africa, separates out coloured and not easily digestible pericarp fraction from the starchy endosperm but with the loss of a part of the germ. The lowered iron content in decorticated pearl millet grains either by hand pounding or mechanically implies that iron is localised in the outer parts of cereal grains (pericarp, aleurone and germ). Decortication also lowered zinc content that was much more substantial in sorghum than in millet due to its primary localisation in the aleurone layer and-germ.

This process also removed phytic acid and fibres. The removal of phytic acid and acid detergent fibre (ADF) contents in the decorticated grains is suggestive of the fact that phytic acid, fibres, and iron, are mainly co-located in the peripheral region of grains.

The removal of phytic acid and acid detergent fibre (ADF) contents in the decorticated grains is suggestive of the fact that phytic acid, fibres, and iron, are mainly co-located in the peripheral region of grains (i.e. pericarp and aleurone layer).In cereals and legumes, endogenous phytase activity enhances during germination and malting by de novo synthesis. Rye, wheat, triticale, buckwheat, and barley are known to produce high endogenous phytase during germination when compared to tropical cereals like-maize-and-sorghum.

Porridge prepared for infant and young by mixing cereal flours from germinated and ungerminated cereals promoted some phytate hydrolysis by essentially the same process.

The hydrolysis of phytate is dependent on the species/cultivar and conditions such as pH, moisture, optimal temperature range (45–57 °C), stage of germination, the presence of inhibitors,-or-the-solubility-of-phytic-acid.

Pearl millet, has the potential for use as a dietary component for tackling micronutrient deficiencies, given its rich iron, and zinc contents, compared to other cereals. However, the bioaccessibility of iron and zinc in pearl millet is reduced, due to the presence of inhibitory factors like phytic acid, polyphenols and fibres. A proper understanding of the localisation of minerals and type of inhibitory factors in pearl millet grain helps in understanding the importance of relevant processing methods to increase mineral bioaccessibility.

Nutritional insecurity is a major threat to the world's population that is highly dependent on cereals-based diet, deficient in micronutrients. Next to cereals, millets are the primary sources of energy in the semi-arid tropics and drought-prone regions of Asia and Africa. Millets are nutritionally superior as their grains contain high amount of proteins, essential amino acids, minerals, and vitamins. Biofortification of staple crops is proved to be an economically feasible approach to combat micronutrient malnutrition. It was realized the importance of millet biofortification and released conventionally bred high iron pearl millet in India to tackle iron deficiency.

Diabetes mellitus

Since the earlier scientific statement, diabetes mellitus screening and diagnosis have changed, with the inclusion of glycated hemoglobin (A_{1c}) of at least 6.5% in the diagnostic criteria of type 2 diabetes mellitus. This change in criteria has identified separate subsets of newly diagnosed patients with diabetes mellitus while the overall diabetes mellitus epidemic continues, with a 75% increase in the number of affected individuals with diabetes mellitus across all age-groups from 1988 to 2010. Fewer than half of U.S. adults meet recommended guidelines for diabetes mellitus care underscoring the magnitude of the public health burden of type 2 diabetes mellitus.

The glycemic index represents the extent of rise in blood sugar in response to a food in comparison with the response to an equivalent amount of glucose. Food with low glycemic index produces small rise in blood sugar level.

The importance of nutrition as a foundation for healthy food development is underestimated. Now-a-days people are very conscious about their healthy living practices to overcome metabolic disorders and life style diseases**.**

Millets offer nutritional security and there is a need for promoting millets as they are highly nutritious. These have been important food staples in human history, particularly in Asia and Africa.

Sorghum Millet

Sorghum and other millets consumption as direct food has significantly declined over the past three decades. The decline in demand has led to the decline in millets production considerably in India. Production of sorghum in India has come down from 7 million tonnes during 2010-11 to 4.2 million tonnes during 2015-16; bajra production was reduced from 10.4 million tonnes to 8.1 million tonnes, production of ragi reduced to 2.2 million tonnes to 1.8 million tonnes and small millets production came down to 0.39 million tonnes from 0.44 million tonnes during the same period.

Sorghum (*Sorghum bicolor)* was the fifth major cereal of the world after maize, paddy, wheat and barley as per FAO production data of 2014. Almost all the millets are used for human consumption in most of the developing countries, but their use has been primarily restricted to animal feed in developed countries.

Sorghum and millets are gluten free, hence, are useful dietary cereals. In general millets are rich source of fibre, minerals and B-complex vitamins. High fibre content and presence of some anti-nutritional factors like phytates and tannins in millets affect bioavailability of minerals. Few studies in humans have suggested that absorption of iron. The world production of millets was 26.7 million metric tonnes from an area of 33.6 million hectare.

Millet Production

Nearly a decade earlier, the world production of millets was down to 23.3 million metric tons from an area of 33.3 million hectare. Africa was the largest producer of millet in 2009 (20.6 million metric tonnes), followed by Asia (12.4 million metric tonnes) and India (10.5 million metric tonnes). Relative to wheat, rice, maize and barley, sorghum ranks fifth in importance, in terms of both production and area planted, accounting for 5% of the world cereal production tends to be lower from millets than from rice or even wheat.

Need for Commercial Diabetic Diet

Millets are used to prepare tortillas mixed with wheat in different ratios to give better quality products. Some food companies are looking for ways of lowering glycemic index of their products in the interest of both marketing advantage and public health. However in United Kingdom some breakfast cereals already have been shown in Glycemic index curves which will be of much significance to consumers.

The challenge of the food industry is to formulate low glycemic index based palatable food items as many people find the foods with glycemic index to be much tastier than the ones with low glycemic index. So the challenge rests in the real of developing the products that equate in taste to a high glycemic index food for gaining an overall high consumer acceptability amongst all age groups as diabetes mellitus is common to all age groups in the present modern era.

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