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Importance of minor millets (Nutri Cereals) for nutrition purpose in present scenario

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Abstract
Minor millets (Nutri cereals) are the groups of small seeded cereals belonging to the family *Poaceae*. There are upto thirty-five species of grasses from 20 genera are well known as small millets. The most important cultivated species of small millets are finger millet, Foxtail, proso millet, barnyard millet, kodo millet and little millet. One of the minor millet namely barnyard millet is the richestsource of calcium content, about 10 times that of rice or wheat. Minor millets are also full of micronutrients like Mg, Ca, Mn, tryptophan, phosphorous, fibre, B vitamins. These micronutrients act as antioxidants which are essential to human body. Additional specialty of minor millets is, they need very less water for their cultivation and can withstand severe climatic conditions. There is need of new high yielding, promotional strategies and policies are necessary to increase the area under nutri cereals crops to achieve nutritional security as well as sustain rainfed farming in the country.

Keywords: Nutri cereals, antioxidants, molecular markers

Introduction
The second green revolution has to be nutrition oriented, which was neglected in production oriented first green evolution, to have inclusive and equitable growth and development of our country. The hidden hunger (Micronutrient deficiency) is very big problems in our country, particularly in the states like Bihar and Orrisa. Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops. Small millets can be grown even in poor soil and in changing climatic conditions. Millets are one of the oldest cultivated food grains known to humans and have been a stable food in Northern Africa for thousand years and was a stable food in China and India prior to popularity of fine cereals like rice and wheat. Millets are tiny in size, round in shape and minor cereals of the small seeded-grass family (Poaceae). It is characterized by their remarkable ability to survive in less fertile soil, drought-resistant, resistance to pests and diseases, short growing season (Devi *et al*. 2004) [6].

These crops have a long history of cultivation of more than 5000 years and grown in many States (Singh and Sharma 2018) [22].They have short growing season and can be very well fitted into multiple cropping systems both under irrigated as well as dry farming conditions. Millets are also unique due to their short growing season. Theses millets are ready to harvest in between 70-80 days. Millets are amazing in their nutrition content (Subramanian *et al*. 2010; Trivedi *et al*. 2015) [23, 25]. Each of the millets is three to five times nutritionally superior to the widely promoted rice and wheat in terms of proteins, minerals and vitamins. They can provide nutritious grain and fodder in a short span of time. Their long storability under ordinary conditions has made them "famine reserves". The government has renamed jowar, bajra, ragi and other millets as “Nutri Cereals”, dispensing with the nomenclature “coarse cereals (Bhat *et al*. 2018) [2].

Madhya Pradesh has highest area of small millets (32.4%) followed by Chhattisgarh (19.5%), Uttarakhand (8%), Maharashtra (7.8%), Gujarat (5.3%) and Tamil Nadu (3.9%). Uttrakhand has highest productivity of 1174 Kg/ha followed by Tamil Nadu (1067 Kg/ha) and Gujarat (1056 Kg/ha) (Anbukkani *et al*. 2017) [1].

According to the consolidated revised National Rural Health Mission (NRHM) report 2012-13 for Bihar, around 80% of children below five years of age in Bihar are malnourished. The NRHM report also says that malnourishment in women in the reproductive age group (15-49 years) has worsened in Bihar (increased to 68.2% in 2012 from 60% in 1998).

Hence, Bihar seems to be trapped in a vicious cycle of malnourished women and children's Millets are amazing in their nutrition content. Over the past three decades, the area under cultivation by these minor millets and their production has been decreased significantly (Vijay kumar *et al*. 2010; Sharma, 2007) [26, 20]. Bihar has also neglected in the adaptation and production of minor millets during the last five decades. Thus, local adaptation and production of minor millets seems to be an important factor influencing its consumption. Initiation of works with respect to collection and evaluation of different millet germplasms with high nutrition and tolerance against abiotic/environmental stresses will add some production enhancement and adoptability of minor millets. Therefore, it has been presumed that there might be some morpho-physiological, biochemical, and molecular approaches are needed for the characterization of minor millets for the adaptation and yield enhancement under optimally even in adverse environmental conditions.

Production pattern

Over the last five decades area under minor millet and finger millet have decreased drastically from 1955-56 to 2013-14. In case of minor millet almost eight fold reduction in area decreased from 53.35 lakh ha in 1955-56 to 6.82 lakh ha in 2013-14. Further the production of minor millet recorded four fold decreases during these periods. However the marginal increase in yield of minor millets was seen but this is very minimal as compared to other crops. In India, millets are cultivated in an area of 15.48 million hectare producing 17.2 million tonnes with a yield of 1111 kg/ha (Directorate of Economics and Statistics, 2015). Maharashtra, Rajasthan and Karnataka are the top most states of millets cultivation in India. Contribution of millets in total food grain production of India reduced from 22.17% to 6.94% over the last six decades from 1950-51 to 2011-12. In spite of all the extraordinary qualities and capacities of millet farming systems, the area under millet production has been shrinking over the last five decades and rapidly, since the Green Revolution period due to relentless promotion of other crops such as rice and wheat for intensive farming in select few resource rich areas under irrigated conditions (MINI). Another major threat that millets facing in the country in the form of an unnatural promotion of maize, which is resulting in maize invasion in various parts of the country owing to the corporate-induced demand for bio-fuels and poultry feed.

Minor millet consumption and its Nutraceutical facts

The concepts of food consumption are changing from previous to present time. Previous emphasis has been on survival, hunger satisfaction, health maintenance and absence of adverse effects on health and current emphasis is on encouraging the use of nutraceutical foods which promise to promote better health and well being thus helping to reduce the risk of chronic diseases such as obesity, diabetes, CVD and cancer.

In spite of several national nutritional intervention programs, India faces huge nutrition challenges as the prevalence of micronutrient malnutrition continues to be a major public health problem, with an associated economic cost of 0.8 to 2.4 per cent of the GDP. Estimates from the most recent National Family Health Survey have indicated that about 46 per cent of the children under five years of age, particularly those living in rural areas, are moderately to severely underweight (thin for age), 38 per cent are moderately to severely stunted (short for age), and approximately 19 per cent are moderately to severely wasted (thin for height). The millets are with higher fibre content, and their protein quality and mineral composition contribute significantly to nutritional security of a large section of population residing in the millet growing areas, considered to be the most disadvantaged groups.

Millets have nutraceutical properties in the form of antioxidants which prevent deterioration of human health (Rao *et al*. 2011) [17]. Millets are most recognized nutritionally for being a good source of minerals magnesium, manganese and phosphorus. Research has linked magnesium to a reduced risk for heart attack and phosphorus is important for the development of body tissue and energy metabolism. Small millets are more nutritious compared to fine cereals. Finger millet is the richest source of calcium (300-350 mg/100 g) and other small millets are good source of phosphorous and iron. The protein content ranges from 7 to 12% and fat content from 1 to 5.0% (Table 1).

Anbukkani *et al*. (2017) [1] reported that minor millets are very rich nutrients and are minerals and resistant to drought and stress in rainfed farming. Consumption pattern of small millets and finger millet was examined by using NSSO unit level data. Assam (18.82 kg/hsh/m) and Bihar (18.69 kg/hsh/m) states have highest consumption of small millets found in all India and rural areas. Minor millets structural break was observed in the year 1998 and between 2000 and 2002. Millets have many nutraceutical properties that are helpful to prevent many health problems such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, decreasing tumour cases etc. Other health benefits are increasing the time span of gastric emptying, provides roughage to gastro intestine (Gupta *et al*., 2012) [8]. Millet is an alkaline forming food. Alkaline based diet is often recommended to achieve optimal health, meaning when it combines with digestive enzymes. The soothing alkaline nature of millet helps to maintain a healthy pH balance in the body, crucial to prevent illnesses. Millets and diabetes Lower incidences of diabetes have been reported in milletconsuming population. Millet phenolics inhibits like α-glucosidase, pancreatic amylase reduce postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates (Shobana *et al*., 2009) [21]. Inhibitors like aldose reductase prevents the accumulation of sorbitol and reduce the risk of diabetes induced cataract diseases (Chethan *et al*., 2008) [4]. Finger millet feeding controls blood glucose level improves antioxidant status (Hegde *et al*., 2005) [10] and hastens the dermal wound healing process in diabetic rats (Rajasekaran *et al*., 2004) [16]. Millets are good sources of magnesium that is known to be capable of reducing the effects of migraine and heart attack. Millets are rich in phyto-chemicals containing phytic acid which is known for lowering cholesterol (Coulibaly *et al*. 2011) [5]. Finger millet may prevent cardiovascular disease by reducing plasma triglycerides in hyperlipidemic rats (Lee *et al*., 2010) [13]. Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Millets are gluten-free, therefore an excellent option for people suffering from celiac diseases and gluten-sensitive patients often irritated by the gluten content of wheat and other more common cereal grains (Saleh *et al*., 2013) [19]. Millets are known to be rich in phenolic acids, tannins, and phytate that act as "antinutrients" However; these antinutrients reduce the risk for colon and breast cancer in animals.

Chandrasekara *et al*. (2011) [3] have demonstrated that millet phenolics may be effective in the prevention of cancer

initiation and progression *in vitro*. Ferulic acid is very strong antioxidant, free radical scavenging and anti-inflammatory activity. Antioxidants significantly prevent tissue damage and stimulate the wound healing process. Rajasekaran *et al*. (2004) [16] have reported good antioxidant effects of finger millet on the dermal wound healing process in diabetes induced rats with oxidative stress-mediated modulation of inflammation. The chemical reaction between the amino group of proteins and the aldehyde group of reducing sugars, termed as nonenzymatic glycosylation, is a major factor responsible for the complications of diabetes and aging. Millets are rich in antioxidants and phenolics; like phytates, phenols and tannins which can contribute to antioxidant activity important in health, aging, and metabolic syndrome (Hegde *et al*., 2002) [9]. Millets fraction and extract have been found to have antimicrobial activity. Seed protein extracts of pearl millet, sorghum, Japanese barnyard millet, foxtail millet, samallmillet and pearl millet were evaluated *in vitro* for its ability to inhibit the growth of *Rhizoctoniasolani*, *Macrophomina phaseolina*, and *Fusarium oxysporum*. Protein extracts of pearl millet are highly effective in inhibiting the growth of all 3 examined phytopathogenic fungi (Radhajeyalakshmi *et al*. 2003) [15].

Table 1: Nutrient composition of millets compared to fine cereals (per 100 g)

Food gain	Carbo-hydrates (g)	Protein (g)	Fat (g)	Energy (K.Cal)	Crude fibre (g)	Mineral matter (g)	Ca (mg)	P (mg)	Fe (mg)
Minor millets									
Finger millet	72.0	7.3	1.3	328	3.6	2.7	344	283	3.9
Kodo millet	65.9	8.3	1.4	309	9.0	2.6	27	188	0.5
Proso millet	70.4	12.5	1.1	341	2.2	1.9	14	206	0.8
Foxtail millet	60.9	12.3	4.3	331	8.0	3.3	31	290	2.8
Little millet	67.0	7.7	4.7	341	7.6	1.5	17	220	9.3
Barnyard millet	65.5	6.2	2.2	307	9.8	4.4	20	280	5.0
Millet									
Sorghum	72.6	10.4	1.9	349	1.6	1.6	25	222	4.1
Bajra	67.5	11.6	5.0	361	1.2	2.3	42	296	8.0
Cereals									
Wheat (whole)	71.2	11.8	1.5	346	1.2	1.5	41	306	5.3
Rice (raw, milled)	78.2	6.8	0.5	345	0.2	0.6	10	160	0.7

(*Source*: Nutritive value of Indian foods, NIN, 2007)

The millet protein has well balanced amino acid profile and good source of methionine, cystine and lycine (Table 2).

Table 2: Essential Amino acid profile of Millets (mg/g of N)

Millet	Arginine	Histidine	Lysine	Tryptophan	Phenyl Alanine	Tyrosine	Methionine	Cystine	Threonine	Leucine	Isoleucine	Valine
Foxtail	220	130	140	60	420	-	180	100	190	1040	480	430
Proso	290	110	190	50	310	-	160	-	150	760	410	410
Finger	300	130	220	100	310	220	210	140	240	690	400	480
Little	250	120	110	60	330	-	180	90	190	760	370	350
Barnyard	270	120	150	50	430	-	180	110	200	650	360	410
Sorghum	240	160	150	70	300	180	100	90	210	880	270	340
Bajra	300	140	190	110	290	200	150	110	140	750	260	330
Rice	480	130	230	80	280	290	150	90	230	500	300	380
Wheat	290	130	170	70	280	180	90	140	180	410	220	280

(*Source*: Nutritive value of Indian foods, NIN, 2007)

These essential amino acids are of special benefit to those who depend on plant food for their protein nourishment. The millet grain contains about 65% carbohydrate, a high proportion of which is in the form of non starchy polysaccharides and dietary fibre which help in prevention of constipation, lowering of blood cholesterol and slow release of glucose to the blood stream during digestion. Lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycemia (diabetes) are reported among regular millet consumers. Millet grains are also rich in important vitamins *viz*., Thiamine, riboflavin, folin and niacin (Table 3). Millets are comparable to rice and wheat or rich in some of the minerals as well as fatty acids. Millets vary largely in composition of carbohydrates as proportion of amylose and amylopectin content vary from 16-28% and 72-84%, respectively. In spite of the extraordinary nutritional qualities of millet grains and capacities of millet farming systems, the area under millet production has been shrinking over the last five decades. The period between 1961 and 2009 saw a dramatic decrease in cultivated area under millets, more so in case of small millets (80% for small millets other than finger millet, 46% for finger millet). The area under all small millets other than finger millet has declined drastically in all states and the total production of small millets has declined by 76%. The productivity has remained more or less stagnant in the last two decades. The area declined by 83% from first five year plan to 11thplan whereas the production also fell by nearly 80%. The productivity of small millets (other than finger millet) remained almost stagnant till 11th plan with a slight decline during 3rd and 4th plans.

Table 3: Vitamin profile of minor millets, millets and cereals

Millet/minor millets	Thiamin (mg)	Niacin (mg)	Riboflavin	Vit A (carotene) (mg/100g)	Vit B6 (mg/100g)	Folic Acid (mg/100g)	Vit B5 (mg/100g)	Vit E (mg/100g)
Foxtail	0.59	3.2	0.11	32	-	15.0	0.82	31.0
Proso	0.41	4.5	0.28	0	-	-	1.2	-
Finger	0.42	1.1	0.19	42	-	18.3	-	22.0
Little	0.3	3.2	0.09	0	-	9.0	-	-
Barnyard	0.33	4.2	0.1	0	-	-	-	-
Kodo	0.15	2.0	0.09	0	-	23.1	-	-
Sorghum	0.38	4.3	0.15	47	0.21	20.0	1.25	12.0
Bajra	0.38	2.8	0.21	132	-	45.5	1.09	19.0
Rice	0.41	4.3	0.04	0	-	8.0	-	-
Wheat	0.41	5.1	0.1	64	0.57	36.6	-	-

(*Source*: Nutritive value of Indian foods, NIN, 2007; *MILLET in your Meals*, http://www.sahajasamrudha.org/)

Millets are nutritionally comparable or even superior to major cereals such as wheat and rice, owing to their higher levels of protein with more balanced amino acid profile (good source of methionine, cystine and lysine). Millets are staple food source, which are not only providing major nutrients like protein, carbohydrates, fats etc but also provide ample of vitamins and minerals. In developing countries malnutrition and various health problems like obesity, diabetes, cardiovascular diseases, cancer, celiac disease etc are most prominent because of inadequate supply of nutrition. This is mainly due to the lack of awareness and knowledge among the people in choosing the kind of food, especially the small millets. Millets are easily available and cheap in cost. Millets contains many major and minor nutrients like carbohydrates, protein, fat, dietary fiber, vitamins and minerals as well as antioxidants and phytochemicals. The importance of this study undertakes to concern and to develop specific agenda for these crops which must be recognized as an important food and to introduce the millets as a nutritious food for fulfillment of the nutritional need of the global population and also to find ways to consume the millets effectively and to reduce the problems of malnutrition and other health problems.

Importance of millet in healthy life

Newly acquired life-styles has now given us diabetes, hypertension and cardiovascular disease running rampant. For the above diseases millets have returned as a viable option to live healthy life without consuming loads of anti-diabetic and anti-hypertension medicines that are not only very expansive but also have serious side-effects in the long run. Minor millets also act as a prebiotic feeding micro-flora in our inner ecosystem. Minor millets will hydrate human colon to keep us from being constipated. The high levels of tryptophan in minor millet produce serotonin, which is calming to our moods. Magnesium in minor millet can help reduce the effects of migraines and heart attacks. Niacin (vitamin B3) in millet can help lower cholesterol. Minor millet consumption decreases Triglycerides and C-reactive protein, thereby preventing cardiovascular disease. All millet varieties show high antioxidant activity. Millet is gluten free and non allergenic.Millets contribute towards balanced diet, and can hence ensure nutritional security more easily through regular consumption along with keeping the environment safe as they are low input crops mostly adapted to marginal lands. Declining small millets cultivation has resulted in reduced availability of these nutritious grains to needy population and also the traditional consumers have gradually switched over to more easily available fine cereals due to Government policies. This is a disturbing trend and needs urgent focus by the agricultural experts and policy makers. Immediate policy and market support, value addition and promotional activity are necessary for arresting the further decline not only in cultivation but also consumption. Improving productivity and enhancing demand should be the twin approaches.

Productivity gaps Even though sorghum, minor millet have seen significant productivity increases, wide productivity gaps remain when a comparison is made between the state average yield (SAY) and outputs from frontline demonstrations (FLD) organized under the Department of Agriculture and Cooperation (DAC). Yield gaps vary between states and per crop, but apply to 'large' and 'small' millets alike. These findings shed light on the enormous potential for improvement, as well as the great challenge that lies ahead.

It is well known that germplasm resources are rich source of useful genes and have been successfully used in traditional breeding efforts to improve several crop plants. Identification of gene based trait specific molecular markers specially linked to nutritional traits will help in controlling these traits. Advent of next-generation sequencing platforms favors rapid sequencing of millet genome and there trait specific characterization. Omics information on millets should advance more rapidly as cereal crops in order to enhance their utilization in the fight against micronutrient malnutrition (Tiwari *et al*. 2018) [24]. Gimode *et al*., (2016) [7] have identified SNP and SSR Markers in Finger Millet by Next Generation Sequencing Technologies using both Roche 454 and Illumina technologies. Wang *et al*., (2017) [27] reported a high-density genetic map and QTL analysis of agronomic traits in foxtail millet [Setariaitalica (L.) P. Beauv.] using RAD-seq and identified 11 major QTLs for eight agronomic traits and five codominant DNA markers were also developed. A finger millet genotype ML-365 sequenced recently using Illumina and SOLiD sequencing technologies (Hittalmani *et al*., 2017) [11]. Recently Kumar *et al*., (2018) [12] reported large effect iron (Fe) and zinc (Zn) content quantitative trait loci (QTLs) using diversity array technology (DArT) and simple sequence repeats (SSRs) markers to generate a genetic linkage map using 317 recombinant inbred line (RIL) population. Many other studies have been focused on drought tolerance and fungal diseases in pearl millet using marker assisted selection approaches.

Conclusion and future prospects

Between 1966 and 2006, 44% of millet cultivation areas were occupied by other crops indicated loss to India's food and farming systems (Dhan foundation). The nutritional superiorities of millets over others cereals are well known, its advantages are not being exploited on commercial scale. Processing and value addition technology advances have

made it possible to process and made available value-added products to households. One of the limiting factors for diversified food uses of small millets is lack of appropriate processing technologies to prepare convenient ready to eat value added products. Therefore, there is an urgent need for Indian policy makers to refocus their attention towards millet farming systems and enact policies that create an enabling environment for millet farmers.

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