ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 10, Issue, 07(I), pp. 33943-33948 July, 2019

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Review Article

MILLETS-REVIEW ON NUTRITIONAL PROFILES AND HEALTH BENEFITS

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DOI: http://dx.doi.org/10.24327/ijrsr.2019.1007.3786

ARTICLE INFO

Article History:

Received 15th April, 2019
Received in revised form 7th May, 2019
Accepted 13th June, 2019
Published online 28th July, 2019

Key Words:

Millets, Phyto-chemicals, Phenolics, Body Immune System, Health, Anti-Diabetic, Anti-Obesity, Cardiovascular disease.

ABSTRACT

Millets have a significant role in the traditional diets of many regions throughout the country. Millets have various advantageous properties like drought resistant, good yielding in areas where water is limited and they possess good nutritive values. Millet are rich with phytochemicals, however, the types and amount present vary greatly between and within different species. The processing techniques used for the grains, like dehulling and decortication, malting, fermentation and thermal processing, etc, have affect on the quantity of phenolics present, mostly helps in reducing them. Therefore the phytochemical levels in millet foods and beverages are considerably lower than in the other cereal grains. There are evidences showing, millet foods and beverages have functional and health-promoting effects, specifically anti-diabetic, anti-obesity, cardiovascular disease, due to the actions of these phytochemicals and play a role in body immune system. However, direct evidence of health-enhancing effects are lacking as most studies have been carried out on the grains and their extracts and not particularly on food and beverage products , and mostly the research work has been conducted *in vitro* or *ex vivo* and not *in vivo*. The current review is to collect the available information from existing literature either online or offline related to the nutritional importance and health benefiting properties of millet and trying to present the collected data in an easily-documented pattern. With the given Nutritional profile and phytochemical contribution of millets, the Nutritionist/ Dieticians must make an effort to encourage the public to consume more millets in general and particular.

INTRODUCTION

Millets are known as one of the most important cereal grains. Millets are consumed by more than 1/3rd of the world's population. It is the 6th cereal crop in terms of world's agricultural production. Millets are *Jowar (Sorghum)*, *Sama* (Little millet), *Ragi* (Finger millet), *Korra* (Foxtail millet) and *Variga* (Proso millet). *Bajra* and *Sama* are high in fat while *Ragi* has the lowest fat. Millets are used as food and are widely used in rural areas. They have been cultivated for a thousand years and are used throughout the world, in the Middle ages the Romans and Gauls were consuming porridges made of millets eaten than wheat. A majority of the world's commercial millet crop is produced by China, India, Greece, Egypt and Africa. But even in rural areas some millets are used for consuming like Finger millet, Sorghum, etc and the remaining are used as animal feed. Millet are having amazing values in their nutrition content. Millets play a significant role in traditional diets in many regions. In many states of India they are using different varieties of millets respectively. All the millets are three to five times higher in their nutrition content when compared to nutritional content of widely used rice and wheat. Wheat and rice provide with security of food while millets give many securities like food, health, nutrition, livelihood, animal feed etc, making millets as yield of agricultural security. Millets are having nutritional and also health benefits and they also help in managing health problems like diabetes mellitus, hyperlipidemia, etc. (Veena, 2003). In India, Karnataka is the leading producer of millets. Over 58% of global production is millets, but very few Indians are acquiring the knowledge of its health benefits and their nutritional value. (Upadhyaya *et al.,* 2007)

Millets

Millets do not require pesticides, according to traditional growing techniques and the land used for growing millets is totally pest free. Millets like foxtail millet are pest free and act as anti-pest agents in storage conditions for pulses like green gram. The millets do not need any fumigants. Millets have relatively a lower position in India, among feed crops in agriculture, but they are very important from food security point at regional and farm level, (Stanley Joseph, *et al.,* 2013). Millets are capable of growing in drought conditions and can withstand higher heat regimes. Millets can grow even in non-

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irrigated conditions and in very low rainfall regimes in between 200mm and 500 mm. Millets can face the low water conditions and can grow. (Millet Network of India, MINI)

Considering the nutritional parameters, millets are way ahead of wheat and rice. In terms of mineral content, millets have more fibre when compared to rice and wheat. Each one of the millets has more fibre than rice and wheat. Some millets have more than fifty times of fibre than of rice. Finger millet is having thirty times more Calcium than rice while all other millets have at least double amount of Calcium compared to rice (Amir Gull, *et al*, 2014). In their Iron content, foxtail and little millet are also high in nutritional content compared to rice.

Millets offer abundant micronutrients like vitamins, beta-carotene etc which are being consumed like pharmaceutical pills in present day. In this present day, all the millets are extraordinarily superior and are therefore, the solution for the malnutrition and obesity that affects a vast majority of the Indian population.

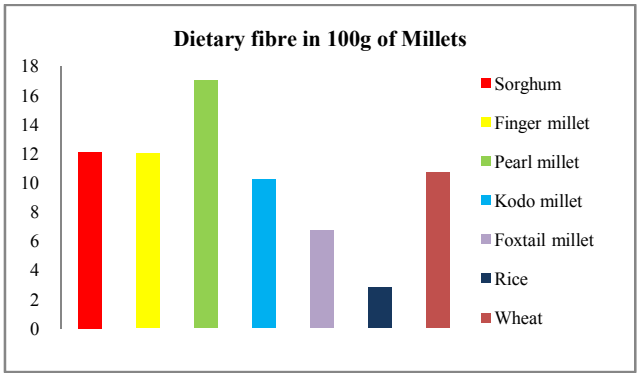

Fig 1 Dietary fibre present in 100g of millets comparing to rice and wheat, Nutritive value of Indian Foods, Gopalan

Anatomy of a Whole Grain Kernel

Bran

Bran is multi-layered outer skin of kernel that helps in protecting the other two parts of the kernel from disease, water, pests and sunlight. The bran has important antioxidants and other minerals and vitamins like iron, zinc, copper, magnesium, B vitamins, fiber, and phyto-nutrients.

Germ

Germ is the embryo, after fertilization by pollen sprouts into a new plant. The Germ contains B vitamins, vitamin E, antioxidants, phyto-nutrients and unsaturated fats.

Endosperm

Endosperm provides the energy to the plant if allowed to grow so it is called as food supply of germ. The endosperm contains starchy carbohydrates, proteins and small amounts of vitamins and minerals.

Millets- Nutrients

Millets have 65% carbohydrates, 9% proteins, 3% fat, and 2-7% crude fibre and vitamins and minerals. They are a good source of vitamin B, magnesium, antioxidants, manganese, phosphorus and also iron. Millets are good source of essential amino acids except for lysine and threonine but are relatively high in sulphur containing amino acids methionine and cysteine (Singh KP *et al.,* 2012). Millets are good source essential fatty acids like linoleic, oleic and palmitic acids found in their free form and monogalactosul, diacylglycerols, digalactosyl diacylglycerols, phosphatidylethanolamine, phosphatdyl serine and phosphatidyl choline in the bound form present in millets. Other fatty acids i.e. arachidic acid, behenic acid, erucic acid are found in trace amounts. Millet oil could be a good source of linoleic acid and tocopherols. Millet is an alkaline forming grain that is gluten-free. Vitamin B such as Niacin, folacin, riboflavin, and thiamine and phosphorus are present in millets that play a key role in energy synthesis in the body (Sarita, *et al.,* 2016).

Table 1 Nutrient value of millets, Nutritive value of Indian Foods, Gopalan

Crop / nutrient	Protein (g)	Fiber (g)	Minerals (g)	Iron (mg)	Calcium (mg)
Sorghum	11	6.7	2.7	3.4	13
Finger millet	7.3	3.6	2.7	3.9	344
Foxtail millet	12.3	8	3.3	2.8	31
Kodo millet	8.3	9	2.6	0.5	27
Little millet	7.7	7.6	1.5	9.3	17
Pearl millet	10.6	1.3	2.3	16.9	38
Proso millet	12.5	2.2	1.9	0.8	14
Barnyard millet	11.2	10.1	4.4	15.2	11

Types of Millets

Sorghum

Sorghum is one of the ancient cereal grain and it is a staple crop in India also in Africa. It is considered as a safe food grain alternative for people with celiac disease and gluten insensitivity. Molecular evidence shows that sorghum grain is completely gluten-free, and provides health benefits that make it a good addition to any diet. Gluten, is a protein which is present commonly in grains like wheat, barley and rye that gives them the chewy, springy quality when baked into breads or pastas. Sorghum used as Wheat replacement for Breads, Pastas, etc.

It is also showed that Sorghum or jowar helps in weight loss. Compared to major cereals like rice and wheat, jowar has a high proportion of calcium. It is also packed with iron, protein and fiber. Researchers have found that a typical sorghum wax is rich in policosanols which helps in reducing the levels of cholesterol. Being a gluten-free grain, it is also much preferred by those who can't tolerate wheat-based products. (O.S.K.Reddy, 2017)

Finger Millet

Finger Millet ia one among the most nutritious cereals and is a good source of natural calcium which helps for bone strengthening and helps in reducing the risk of bone fractures. It is also a good source of natural iron helping in Anaemia.

Finger Millet is considered as a good nutritious food which can be replaced in place of rice or wheat. It is considered as store house of nutrients rich in proteins, aminoacids, minerals and vitamins. With its rich fibre content, it is a good laxative and helps to prevent constipation.

Finger millet is a good for infants, elderly and pregnant women due to its high calcium content. It is also very good for lactating women as it helps in producing sufficient breast milk.

Finger millet helps in different disease condition like blood pressure, heart problems, asthma and is very good food for diabetes where it helps in slow digestion and slow release of glucose in blood.

Finger millet helps to increase the hemoglobin level and helps to fight malnutrition and degenerative diseases (O.S.K.Reddy, 2017)

Pearl millet

Pearl millet consists of magnesium which helps in reducing the respiratory problems in asthma patients and helps to reduce the effect of migraine. The fibre content of pearl millet helps the reduction of gall stone occurrence. The insoluble fibre present in pearl millet help in reduction of excessive bile in our system, as excessive bile in our system leads to gall stones (Shweta, 2015).

Kodo millet

Kodo millet are traditional food which closely resembles the rice and helps to use in weight loss. It is easily digestible and is rich in phytochemicals and antioxidants which helps in preventing different lifestyle related diseases. Kodo mill*et al*so helps in reducing the joints and knee pain and helps in regularizing the menstruation in woman (Deshpande *et al*., 2015).

Proso millet

Proso millet is beneficial in preventing Pellagra condition, which is caused due to the niacin Vitamin B3. Proso millet has high content of Niacin. Pellagra is a skin disease which causes the skin to become dry, scaly and rough. Proso millet consists of protein and niacin (Vitamin B3). Traditionally it is used as recuperative food, especially post pregnancy or illness (Jana Kalinova, 2007)

Foxtail millet

Foxtail millet helps in steady release of glucose without affecting the metabolism of the body. When people consume foxtail millet, the prevalence of diabetes is reduced and it is also known as healthy heart food due to its good source of magnesium (O.S.K.Reddy, 2017)

Little Millet

Little millet is highly nutrition and may be called little but it not less in its nutritional content. It has good source of B-vitamin, minerals like calcium, iron, zinc, potassium among others. It also provides essential fats to the body, the kind that helps in weight loss. Its high fiber content is yet another positive making it an ideal part of pongal or even kheer instead of rice. (O.S.K.Reddy, 2017)

Table 1 Types of Millets

Health Benefits of Millets

Millets - Obesity

Obesity is the biggest emerging problem in India and it is associated with several chronic diseases including diabetes and CVD. Recent studies show that intake of high dietary fibre decreases the incidence of obesity (Alfieri *et al.,* 1995). Foods rich in dietary fibre improves the bowel function and slows the process of digestion and absorption, thereby reducing the risk of chronic diseases (Ali *et al.,* 1982). The dietary fibre content present in millets is 22% which is comparatively higher than other cereals like wheat having 12.6%, rice having 4.6%, maize having 13.4%. Chethan, *et al.,* (2007), reported that there is 15.7% insoluble dietary fiber, 1.4% soluble dietary fiber, in finger millet grain. Shobana, *et al*., (2007) has reported that finger millet is having 22.0% total dietary fiber, 19.7% insoluble dietary fiber and 2.5% soluble dietary fiber. As we know that dietary fibres are classified into soluble fibres and insoluble fibres.

Now a days it is seen that Obesity has become an emerging problem which is associated with several other diseases like Diabetes, Blood pressure and Cardiac problems. Studies suggested that consuming high fibre food helps in improving the bowel function and reduce the prevalence of Obesity by improving the digestion and absorption in the body thereby reducing the risk of chronic diseases. Millets helps in satiating hunger satisfaction and helps in weight management reducing obesity.

With high fibre content, millets help to reduce problems like constipation, flatulence, bloating and stomach cramping. With good digestion and absorption, the retention of gastro-intestinal illnesses like ulcers and colon cancers (O.S.K.Reddy, 2017).

Millets-Diabetes

Millets showed the results by reducing the α-glucosidase and pancreatic amylase thereby reducing the postprandial hyperglycemia by reducing the enzymatic hydrolysis of complex carbohydrates. The enzymes like aldose reductase which helps in prevention of accumulation of sorbitol and reduces the risk of diabetes induced cataract diseases. Hence consuming millets helps controlling the blood glucose level and also helps in dermal wound healing process with the help of antioxidants (Rajasekaran NS, *et al.,* 2004).

National Institute of Nutrition (ICMR) in 2010 assessed Glycemic Index (GI) of sorghum based foods in collaboration with the Indian Institute of Millets Research, Hyderabad under National Agricultural Innovation Project (NAIP). The results showed that sorghum based foods are having low GI and reduces the postprandial blood glucose level. Finger millet diets showed low glycemic response due to high fiber content. They also help in dermal wound healing process. Studies have strong evidence for finer millets protein in inhibiting the cataractogenesis in humans

As we see that Diabetes is a disease is found in millions of people throughout the world. Millets help in prevention of Type II Diabetes due to their significant levels of magnesium. Magnesium is an important mineral which helps in increasing the efficiency of Insulin and glucose receptors by producing many carbohydrate digesting enzymes, which manages insulin action. (O.S.K.Reddy, 2017)

Millets-CVD

Millets showed the results that by consuming the porso-millet protein concentrate, it has the effect on plasma lipid levels and clearly showed that the plasma high-density lipoprotein

cholesterol and adiponectin levels are elevated (Kyung, *et al*., 2008). Millets are also a good source of magnesium which is known for the reducing of heart attack. Millets which are known to be rich in phyto-chemicals which contains phytic acid helping in lowering cholesterol and preventing cardiovascular disease by reducing plasma triglycerides (Lee, *et al.,* 2010). Studies suggested suggested that regular consumption of whole millet grains reduces the risk of CVD.
Millets are one of the best possible grains to add to your diet if you want to protect your heart, which is something that everyone can relate to. Millet is a rich source of magnesium, which is an important mineral for reducing blood pressure and the risk of heart attacks of strokes, particularly in the case of atherosclerosis. Millets are also a great source of potassium, which further keeps blood pressure low by acting as a vasodilator. Reducing your blood pressure and optimizing your circulatory system is one of the best ways to protect your cardiovascular health.

Furthermore, the plant lignans of millets are prebiotic fiber which are fermented in our intestinal gut by bacteria can be converted to animal lignans by the micro flora in our digestive system and those animal lignans have been shown to protect against certain chronic diseases. Upon fermentation, they yield enterolactone, a product which is known to protect against heart disease and also some forms of breast cancers. (O.S.K.Reddy, 2017)

Millets and Cancer

Millets showed results that they are rich phenolic acids, phytates and tannins which are the antinutrients which help in reducing the risk for colon and breast cancer. It is showed that phenolics in millets are effective in preventing the cancer initiation and progression *in vitro* (Chandrasekara A, *et al.,* 2011). Millet have linoleic acid which contain anti-tumor activity (nobihoru, *et al*., 2007).

Anti-carcinogenic properties of sorghum have been well documented. The polyphenols and tannins present in sorghum have anti-mutagenic and anti-carcinogenic properties (Grimmer *et al*., 1992) and can act against human melanoma cells, as well as positive melanogenic activity. China and in different parts of the world (Van Rensburg, 1981) showed that Incidence of oesophageal cancer was low with sorghum consumption. In each country, the authors studied 21 communities over a period of 6 years and found consumption of sorghum showed lower mortality from oesophageal cancer than wheat and corn

Many of the antioxidants found in millets, in addition to their beneficial impact on neutralizing free radicals, which can cause cancer, they can also clean up other toxins from your body, such as those in your kidney and liver. Quercetin, curcumin, ellagic acid, and various other beneficial catechins can help to rid your system of any foreign agents and toxins by promoting proper excretion and neutralizing enzymatic activity in those organs. (O.S.K.Reddy, 2017)

Millets and Celiac Disease

Celiac disease is a genetically susceptible problem triggered by the consumption of gluten. As the millets are gluten free, they help in reducing the celiac disease by reducing the irritation caused by the common cereal grains which contain gluten. (Saleh ASM, *et al.,* 2013*)*.

Regulating digestive process can increase nutrient retention and reduce chances of more serious gastrointestinal conditions like gastric ulcers or colon cancer. Fiber content in millets helps in eliminating disorders like constipation, excess gas, bloating and cramping. An immune mediated enteropathic disease called celiac disease which is usually triggered by the ingestion of gluten in susceptible individuals (Catassi and Fasano, 2008). A gluten free diet primarily plays a major role in affecting food consumption in the grain food group. Replacing cereals like wheat, barley, rye-based foods made from gluten free grains, including rice, corn, sorghum, millet, amaranth, buck wheat, quinoa, wild rice may help people adhering to gluten free diet. (Thompson, 2009). As millets are gluten free, they have considerable potential in foods and beverages and can meet the growing demand for gluten free foods and will be suitable for individuals suffering from celiac disease.

Millets and Phytochemicals

Millets, are good source of phytochemicals and micronutrients. Phytochemicals like phenolics, sterols, lignans, inulin, resistant starch, β-glucan, phytates, tocopherol, dietary fiber and carotenoids are present in millets. The polyphenols are the phenolic acids and tannins, flavonoids are present in small quantities; which act as antioxidant and play a role in the body immune system (Chandrasekara A, *et al.,* 2010).

Many of the antioxidants found in millet have beneficial impact on neutralizing the free radicals, which can cause cancer and clean up other toxins from body such as those in kidney and liver. Quercetin, cucurmin, ellagic acid and various other beneficial catechins can help to clear the system on any foreign agents and toxins by promoting proper excretion and neutralizing enzymatic activity in those organs. Therefore, tremendous attention has been given to polyphenol due to their roles in human health (Tsao R, 2010). 54 F Nutritional and Health Benefits of Millets The antioxidant, metal chelating and reducing powers are shown by the soluble and insoluble bound phenolic extracts of several varieties of millet (kodo, finger, foxtail, proso, pearl and little millets) (Chandrasekara and Shahidi, 2010). Foxtail millet contains 47mg polyphenolics/100 g and 3.34 mg tocopherol/100 g (wet basis); however, proso millet contains 29 mg polyphenolics/100 g and 2.22 mg tocopherol/100 g (wet basis). Millets are highly nutritious and helps in various health benefits. Millets help in fighting Obesity.

Table 2 Health benefits of Millets

Millet properties and their health benefits				
Millets	High fibre content	Sugars are slowly released	Helps in diabetes Helps in constipation, Intestinal cancer.	Veenu Verma., *et al*, (2012)
	Gluten free	Complex carbohydrate	Helps in Celiac disease	Dayakar Rao., *et al*, (2013)
	Phytochemicals	Phenolic acids and flavonoids	Overall health management	FereidoonShahidi., *et al*, (2013)
	Neutraceuticals	Anitioxidant activity	Prevent disease risk	Palanisamy Bruntha devi., *et al* (2014)
		Anti microbial	Helps as prebiotic and probiotic Anti diabetic Anti tumerogenic	

DISCUSSION

Millets are the foods which are the least allergic and which are easily digestible and is the best food for gluten sensitive patients. Millets are plenty with essential aminoacids, fattyacids and dietary fibre.

1. For the proper functioning of the body, it requires many healthy nutrients and millets have many healthy nutrients. The contain minerals like iron and copper, which are required for the production of the blood cells and for improving blood oxygenation. They also contains phosphorus which help in controlling blood pressure. Thereby help in defence activity of the body against diseases.
2. When millets are consumed in large quantities, they help in reducing the triglyceride in the body thereby preventing the blood platelet clumping and also reduces coronary artery diseases.
3. Millets contain vitamins like vitamin-B which helps in easy breakdown of carbohydrate and fats. They help in reducing the homocystine level in blood preventing the bonding of cholesterol and forming deposits. Niacin help in increasing the HDL by preventing cholesterol from blood stream. They protect the blood vessels from blood hemorrage and atherosclerosis.
4. The protein structure present in millets is similar to wheat but the only difference is that millets are no-gluten grains. Due to the excellent protein source, the millets are mostly utilized by vegans or vegeterians. Millets have excellent plant protein which is better than animal protein and has no saturated fats.
5. Millets has tryptophan which is an aminoacid which helps in maintaining the healthy body weight by lowering the appetite. Millets have the high amount of fibre which helps to satiate hunger quickly and helps in preventing overeating millets help in weight management diets.
6. Millets help in reducing the risk of colon cancer, as they contain both fibres and phytonutrients. Lignans which is present in millets helps from breast cancer as it is converted into mammalian lignan.
7. Magnesium present in millets helps in relaxes muscles of arterial wall, reducing blood pressure. Also helps in reducing the severity of asthma and frequency of migraines.
8. Millets being gluten free are the perfect food for people who suffer from celiac disease as they cannot digest and tolerate gluten.

- Millets with important health benefits, reduces the risk of heart diseases, millets help from diabetes, improves the digestive system, helps in respiratory health, helps in fighting cancer, helps in several degenerative diseases like metabolic syndrome, improves the neurological and muscular systems, improves respiratory health etc (Manach *et al.,* 2005). The nutrients which are present in millets are resistant starch, lipids, oligosaccharides, antioxidants such as phenolic acids, flavonoids, lignans and phytosterols which are responsible for number of health benefits (Edge *et al.*, 2005).
- Sorghum is rich in dietary fibre, chemical characteristics and has unique physical characteristics which help in adding bulk to the diet, viscosity, water holding and absorption capacity, which determine the subsequent physiological behaviour. It also helps in the hunger satisfaction and helps in satiety and thereby reducing the risk of development of obesity. Its Gluten free properties help in Celiac Disease. (Dayakar Rao., *et al*, (2013)
- Finger millet helps in losing weight, Ragi is having an amino acid called Tryptophan which helps in lowering of appetite and helps in weight control. Finger millet is digested at a slower rate which helps in keeping away the intake of excessive calories. And, fibres of finger millet gives fullness feeling thus controlling the excessive food consumption (ICAR - Indian Institute Of Millets Research, 2017 (IIMR)
- Pearl millet aids in weight loss by reducing the satiety. Pearl millet with its high fibre content and longer grains helps in slow movement of food from stomach to the intestine. Thus helps in longer duration of food intervals and helps in weight reduction. Thus millets have great potential in helping to fight Obesity. Consuming millets helps in fighting Obesity and therefore helps in fighting metabolic disorders. Millets are indeed the miracle grains, which are available at a lower cost but giving higher nutritional benefits.
- Magnesium in millets can help reduce the affects of migraines and heart attacks. Niacin (vitamins B3 & B6) in millets can help lower the cholesterol, Phosphorus in millets help with fat metabolism, body tissue repair and creating energy (phosphorus is an essential component of adenosine triphosphate or ATP, a precursor to energy in your body), Millet can help lower risk of type 2 diabetes, Fiber from whole grains has been shown to protect against breast cancer and whole grains have been shown to protect against childhood asthma.

CONCLUSION

Now it is an established fact that the whole world is facing many health challenges because of fiber-less foods. It is also clear to 1000s of patients that all the lifestyle diseases can be made to disappear just by eating millets for breakfast, lunch and dinner and removing refined foods like rice, wheat, refined flours, processed meats, refined oils, packed & ready to consume -kind of foods and milk. Millets have multiple health benefits to include these ancient prized grains-like seed in our regular diet. Most of the civilized people have not even heard about millets and much less understand the benefits of millet nutrition. And yet, millet is one of the best-kept secrets of our ancient ancestors. Traced back to its origin in China, millets have been used throughout the ages and across many countries. Millets are even mentioned as treasured crops in the Bible.

The aim of this study is to help the people to recognize the importance of food and to introduce the millets as a nutritious food, fulfilling the nutritional need of global population and to find ways to consume the millets nutritionally, effectively and to reduce the problems of malnutrition and other health problems. All the millet foods are having significant health

benefits, with their rich content of nutrients like fibre which helps in metabolic disorders like Diabetes, Obesity, Cardiovascular diseases etc, their good protein content which helps in child growth and development, with calcium content which helps in the bone development in both children and geriatric people, with good iron content helps in ailing of anaemia and with gluten free characteristics helps the celiac disease patients and helps in gluten insensitivity. Phytosterols and policosanols are cardio-protective compounds present in the waxy layers of the millet. If these millets are ground into flour without de-hulling, then one can have multiple benefits. Millets have antioxidants, which are substances that may protect your cells against the effects of free radicals.

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