Potential Health-benefits of Millets "Nutri-Cereals"-A Review.

Sunita Mishra[1]*, Rajani Singh[2]

[1]Professor, Dept. Food and Nutrition, Babasaheb Bhimrao Ambedkar University, Lucknow
[2]Research Scholar, Dept. Food and Nutrition, Babasaheb Bhimrao Ambedkar University, Lucknow

Abstract

Millets are one of the initial foodstuffs consumed by humans and perhaps the first cereal grain employed in household cooking. Since ancient times, millets have been a primary source of nutrition for the inhabitants in semi-arid tropics in Asia and Africa, where other crops do not thrive. India and Asia have both been major millet consumers for centuries. Millet seeds are ground to create the Indian flatbread known as roti. The area used for millet cultivation has been declining over the previous 50 years, especially since the green revolution period, despite all these outstanding traits and capacity of millet farming systems. The little "grain" is free of gluten and rich in vitamins and minerals. Good quality protein, minerals, dietary fibre, phytochemicals, and vitamins are all abundant in millet grain, which is also extremely nutrient-dense. As compared to rice and wheat, millets' nutritional profiles are examined. Foxtail millet, proso millet, and pearl millet all have protein levels that are higher than those of wheat. Kodo, little, foxtail, and barnyard millet have higher fibre contents. Interestingly, finger millet has 344.00 mg of calcium per 100g. Millets are added to cereal-based food products, which have grown in popularity due to their nutritional and practical advantages. As consumers believe millets and meals made from millet directly affect their health, value-added millet products have the potential to bring value to businesses and have significant growth potential. In order to further raise public awareness of millets' positive effects on health, the UN declared 2023 as the "International Year of Millets." Here in this review article we are discussing about the cultivation, nutritive value, health benefit and the various uses of millets.

Keywords: Millets, Health benefits, Phytochemical, Nutri-cereals, Underutilized crops, Nutritional value.

Introduction

Since the beginning of agriculture, millets and grains have been an essential part of the human diet. They were important in the development of civilization, which coincided with the production of cereal grains [1,2,3]. Millets are distinct from one another in terms of their morphological characteristics, maturity, grain type, and appearances. On the other hand, these crops are underutilized and neglected due to their lower cooking quality, poorer preference due to prosperity, and higher processing time and effort. If these issues could be remedied, their high nutritional value might increase their worth as a food source for farmers and as a potential source of revenue [4]. The reduction of dietary preferences caused by advancements in the productivity increase and processing of dominating crops like rice, wheat, maize, and some others has resulted in the underutilization of many other crops [5]. Small-seeded, widely cultivated, highly nutritious millets are crops that can endure drought conditions and are produced with a minimum amount of irrigation. They normally have a short growing season, are pest-free, and don't need additional fertilizer for development. There are around 200 underutilised crop species for various socio-geographic and economic zones throughout the world, of which 29 are millet species, according to research by Biodiversity International (BI USA), National Academy of Sciences (NAS USA), and International Centre for Underutilised Crops (ICUC) (5). In many parts of the world, particularly in India, China, and some regions of Africa, millets serve as an indigenous crop consumed as a staple food. The traditional Kannada saying "A rice eater is always weightless like a bird; A jowar eater is strong like a wolf; A ragi eater is always disease-free" is well known in India. one of the reasons for the early cultivation of millets is their resilience and adaptability to various growing conditions. millets are known to tolerate harsh climates, poor soil fertility, and low rainfall, making them suitable for cultivation in regions where other crops may fail. Their resilience, adaptability and nutritional value have contributed to their cultivation and consumption by various civilizations throughout history [6]. Millets serve as a staple in many Indian states' conventional diets, and different types are consumed throughout the country. India is currently dealing with both the phases of advancements before and after, functioning in a progressive

***Correspondence to:** Sunita Mishra, Dept. Food and Nutrition, Babasaheb Bhimrao Ambedkar University, Lucknow, E-mail: sunitabbau@gmail.com

***Received:** 27-July-2023, Manuscript No. AAPCGP-23-108256; **Editor assigned:** 29-July-2023, PreQC No. AAPCGP-23-108256(PQ); **Reviewed:** 14-Aug-2023, QC No. AAPCGP-23-108256; **Revised:** 17-Aug-2023, Manuscript No. AAPCGP-23-108256(R); **Published:** 24-Aug-2023, DOI: 10.35841/aapcgp-6.5.161*

***Citation:** Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

way, and putting every effort to earn the designation of a developed country. Pre-progress problems include basic problems like the absence of nutritious food and specific deficiencies like a lack of iron, calcium, and other nutrients, whereas post-progress problems include things like obesity, diabetes, cardiovascular disease, etc. [7]. The Global Hunger Index (GHI) has given India a very low rating, and on the other hand, the rates of malnutrition, obesity, and cardiovascular diseases are also rising at an alarming rate. Several studies, reviews, and reports show that India is going through a transformation and addressing both issues (GH Index 2019). The World Health Organisation (WHO) defines malnutrition as deficits, excesses, or irregularities in a person's consumption of food and energy (WHO and World Bank 2019). In India, the rate of ill healthy children, young adults, pregnant women, and nursing mothers is high. It has an impact on newborn children in a variety of ways, such as poor immune systems, chronic illnesses, survival, correct organ development, etc. According to the most recent UNICEF report, 2019 (UNICEF 2019), malnutrition is responsible for 69% of child fatalities under the age of five in India, and the infant mortality rate is 8.8%. Additionally, India has significantly increased its contribution to the rise in the number of people with diabetes. India is referred to as the diabetic capital of the world due to the constant increase in the number of diabetes sufferers (GH Initiative 2019). Millets are popular small-seeded annual grasses or cereals that are native to Ethiopia and are members of the Poaceae family. They have been successfully introduced to India, China, Australia, Africa, and some parts of the United States of America (U.S.A.). Millets may be grown without any application of pesticides since they are disease-resistant [8]. Millets are stress-tolerant grains that can thrive in poor soil or with less nutritional requirements, are resistant to temperature variations, and have a distinct short growing season [9]. These may grow in soggy or damp places to drought zones, as well as dry and semi-arid environments [10]. Pearl millet, proso millet, foxtail millet, and finger millet are the most important millet crops in India, but quinoa, kodo millet, barnyard millet, and tiny millet are also grown. Millets offer the majority of the population's energy and protein needs in their farming region.

Millets have a large quantity of dietary carbs (60-70%), dietary fibres (10-12%), protein (6-9%), a low level of fat (1.5-5%), and a significant number of minerals (2-4%) [11].

Scope

Millets are abundant in protein, dietary fibre, essential fatty acids, and minerals such as potassium, zinc, magnesium, calcium, iron, and vitamins, particularly vitamin-B complex. Millets also aid in the prevention of several ailments such as diabetes, cardiovascular disease, blood pressure, thyroid disease, and celiac disease by keeping blood pressure and sugar levels stable [6]. These are classified as Nutri-cereals due to their high nutritional value. Nutri-cereals are extremely nutritious grains that have a comparable quantity of nutrients as staple food, according to the Indian Council of Agricultural Research and Indian Institute of Millets Research (ICAR-IIMR).

To address all of these pre and post-progression issues, greater research into a high-quality replacement staple meal is required. India is well-off in terms of food security. Other millets and cereals are consumed as food in addition to rice and wheat. India is promoting foxtail millet, barnyard millet, quinoa, and pearl millet. All of these food crops are rich in supplements, but they are becoming obsolete due to our shift away from rice and wheat. Millets are a collection of highly seeded tiny annual grasses that are extremely resistant to drought and other extreme weather conditions. Millets are widely used throughout Asia and Africa's tropics and subtropics, particularly in India, Nigeria, and Mali [12]. Millets have similar levels of protein, nutrients, iron, calcium, fibre, high density lipoprotein (HDL), cancer-prevention agents, and are gluten-free, making them Nutrigrains [10]. So, in order to strengthen efforts against food crises, pre and post-harvest problems, and to support and encourage farmers to produce millets and agri-industries to use millets, the Government of India declared 2018 as the national year for millets production and later forwarded a proposal to the United Nations (U.N.) to declare 2018 as the "international year for millets".

The largest concentration of flavonoids is found in finger millet. This is due to the fact that the quantities of flavonoids vary significantly amongst millet species, particularly finger millet and pearl millet. Flavonoid levels are greater in red and brown coloured millet species due to the presence of anthocyanin flavonoid-type pigments. According to the literature, foxtail millet, pearl millet, and proso millet have greater levels of phenolic acids. However, because they are cell wall bound, a large portion of their phenolic acid content is insoluble and may not be bioavailable. In terms of tannins (proanthocyanidins/procyanidins), finger millet is thought to be the only millet that includes tannins in some of its brown variants [13]. Millets are a type of nutri-cereal that possess numerous health benefits. They are rich in dietary fiber, which aids in digestion and promotes a healthy gut. Millets are also a good source of various vitamins and minerals, making them a small and large scale supplement for overall health. One important characteristic of millets is that they are gluten-free, which makes them suitable for individuals with gluten intolerance or celiac disease. They are also alkaline in nature, helping to balance the body's pH levels. Millets are considered as an excellent fortification agent or fortificants. They can be used to enhance the nutritional value of various food products, especially in regions with nutritional deficiencies. These nutri-cereals are known to be intestinal-friendly, meaning they promote a healthy bowel movement and prevent constipation. They are also rich in antioxidants and phenolic compounds, which have anti-inflammatory and disease-fighting properties. Millets contain compounds that help in promoting overall well-being. They are easily digestible and rich in lecithin, which supports the functioning of the sensory system. Consuming millets can also have a positive impact on cholesterol such as LDL and VLDL, as well as triglyceride levels. This can greatly reduce the risk of cardiovascular problems. Furthermore, millets have been shown to have anticancer properties and may help in preventing a variety of cancers [14].

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

Types of Millets (Nutri-Cereals)

Pearl millet (*Pennisetum glaucum*)

Pearl millet, also known as Bajra, is popular indigenous millet that grows well on sandy soil and requires little watering [14]. Pearl millet may be readily preserved at low temperatures and moisture conditions due to its increased oil content (4-9%) [15]. Pearl millet is a type of millet that is commonly consumed in many parts of the world. Its flour is used for baking various bakery products and is an essential ingredient in traditional food items such as flatbreads. These are considered as a good source of both macro and micronutrients. It is high in dietary fiber, which aids in digestion and helps regulate cholesterol levels. The phytochemicals present in pearl millet, such as photosterols, have been linked to reducing cholesterol levels and promoting a healthy lipid profile. Pearl millet is rich in several key micronutrients. It is particularly high in folate, an important vitamin for DNA synthesis and the prevention of neural tube defects in pregnant women. Additionally, pearl millet contains significant amounts of minerals like copper, zinc, iron and maintaining healthy bones and muscles. The grain is also a source of calcium, which is crucial for bone health and teeth strength. Furthermore, pearl millet is known to provide a good amount of B complex vitamins, including thiamin, riboflavin, niacin, and vitamin B6. These vitamins play vital roles in energy metabolism, brain function, and the maintenance of a healthy nervous system. Pearl millet contains unsaturated fatty acids, particularly omega-6 and omega-9 fatty acids. These healthy fats are beneficial for heart health and inflammation reduction [14]. Its high folate content makes it a bio fortifier against anemic populations, while the presence of magnesium can aid in the treatment of headaches and lessen respiratory issues in asthmatic individuals [6]. Pearl millets also include phytonutrients such as apigenin, flavonoids, lignin, and myricetin, which aid in the prevention of breast cancer and cardiovascular disease, as well as anti-fungal and anti-ulcerative properties [8]. [16] has shown that foxtail millets have an anti-ulcer reaction as well as a ubiquitous antioxidant impact and protect the stomach mucosa.

Barnyard millet (Echinochloa spp.)

Barnyard millet is a quickly growing millet crop that is typically harvested in 6 weeks and is also known as Swank or Shyama [17]. It is high in protein, dietary fiber, and certain soluble and insoluble components, as well as low in carbohydrates. It is mostly composed of three fatty acids: linoleic acid, palmitic acid, and oleic acid. Barnyard millet is particularly good in lowering blood sugar levels and, because it is gluten-free, it also protects against celiac disease [14]. It includes anti-oxidative phenolic chemicals, flavonoids, and serotonin derivatives and has extremely high anti-oxidative action [18]. Its main components include luteolin, N-(p-coumaroyl), serotonin, and tricin, which are anti-cancerous, anti-rheumatic, and anti-diabetic [8].

Little millet (*Panicum miliar*)

Gajrao is a popular name for little millet. It has 37-38% dietary fibre and high protein content. It may be used to make snacks, infant meals, processed foods, and many more [14]. It includes apigenin, which aids in the treatment of diabetes, celiac disease, cardiovascular disease, high cholesterol, and is anti-cancerous [8]. little millets are especially helpful for wheat intolerant persons since they are abundant in phosphorus, iron, and vitamin B. Germinating little millets are good sources of a-amylase with better purity and specific yield [19]. The soluble portion of little millets has around 80% phenolic (caffic, ferulic, and sinapic acids) and flavonoid (kaempferol and luteolin) content [20].

Foxtail millet (*Setaria italica*)

Foxtail millet, also known as Kangni in India, is the second most often produced millet. These are often grown in semi-arid climates and require less watering. Foxtail millets are antipest and high in protein, dietary fibre, calcium, vitamins, iron, and copper. They also aid in disease resistance ability [14]. It is non-acid-forming and non-glutinous, making it easily digested. It aids in the steady release of glucose in the body while without interfering with human metabolism [5]. It includes catechin, quercetin, apigenin, and kempherol, which aid in the treatment of diabetes, cardiovascular disease, and the maintenance of dyslipidemia. It is recognised as a good heart meal because of its magnesium concentration. It is antimicrobial, antitumorgenic, and aids in the purifying of the body [8]. [16] has shown that foxtail millets have an anti-ulcer reaction as well as a ubiquitous antioxidant impact and protect the stomach mucosa.

Finger millet (*Eleusine coracana*)

Finger millet is a yearly, dry-season crop that requires fairly consistent precipitation. The use of finger millet includes both conventional and non-traditional processing techniques, including soaking, malting, boiling, fermentation, popping, and radiation [3]. It has a high protein content, dietary fibre, vital amino acids, vitamin A, and vitamin B [14]. It also contains a lot of calcium (10 times more than rice and wheat) and phosphorous, which helps with high blood cholesterol, constipation, and intestinal cancer [10]. It is regarded as the greatest diabetic diet since it regulates hyperglycemia and blood sugar levels [14]. It also has catechin, myricetin, epicatechin, tricin, epigallocatechin, luteolin, taxifolin, kempherol, vitexin, daidzein, gallocatechin, pyrocyanidin B1, apigenin, and pyrocyanidin B2, all of which are important in the treatment of diabetes and cardiovascular disease. Finger millets have antimicrobial and anticancer properties [8]. [21] Reported that Flavonoids and phenolic compounds inhibits the growth of pathogenic bacteria such as *Bacillus cereus, E. coli, Klebsiella pneumonia, Listeria monocytogenes, Proteus mirabilis, Pseudomonas aeruginosa, Serratia marcescens, Staphylococcus aureus, Streptococcus pyogenes, and Yersinia enterocolitica*.

Another study suggests that an instant health beverage powder supplement or a finger millet extract might be used to address calcium-deficient disorders.

Quinoa (*Chenopodium quinoa*)

Quinoa is a pseudo-cereal or pseudo-grain due to its high protein content; it can grow at an altitude of roughly 3500-

4000 above mean sea level (MSL) in cold and high climatic zones and is used in cooking, baking, or as green fodder, animal feed, and pellets [22]. Because of its greater mineral, protein, and vitamin content, it gained a lot of attention from Asia, Europe, and the United States. Quinoa cultivating is practiced in India at high altitudes in the Indian Himalayan region [23]. It includes flavonoids, polyphenols, and phytosterols, all of which may have Nutraceuticals effects. It is high in protein, dietary fiber, minerals, and vitamins, which aid in the treatment of diabetes, protein-energy deficiency, celiac disease, dyslipidemia, cardiovascular disease, and intestinal health [24]. It includes iron, magnesium, copper, phosphorus, potassium, and zinc, as well as the amino acids lysine and methionine, which are missing in grains. Furthermore, quinoa is classified as an oil crop due to its high concentration of accessible oil, omega-6 fatty acid, vitamin-E, and vitamin-B [25].

Sorghum (*Sorghum vulgare*)

Sorghum, also known as Jowar, is a traditional staple grain for the world's dryland people. Sorghum is the fifth most-produced crop in the world, and the fourth in India. It has more nutritional value than rice and includes b-carotene, folic acid, fibre, thiamine, and riboflavin [14]. Sorghum has a high concentration of condensed tannins, flavonoids, and phenolic acids. Its antioxidant and pigment levels are comparable to those of vegetables and fruits. Sorghum is anti-carcinogenic and reduces the risk of esophageal cancer [26]. It also includes protein, vitamins such as B1, B2, and B9, important minerals such as calcium, iron, potassium, phosphorus, salt, and zinc, and dietary fiber. Sorghum is a highly nutritive and prosperous millet with more nutritional value than rice or wheat and Nutraceuticals properties that aid in the treatment of both pre and post transition problems such as arthritis, heart-related cardiovascular diseases, lower body weight and body mass index (BMI), malnutrition, obesity, and so on [27].

Kodo millet (*Paspalum scrobiculatum*)

Kodo millet is a drought-resistant, pest-resistant, thermophilic xerophyte plant native to Africa's subtropical and tropical areas that has become indigenous Indian millet after being domesticated here some 3000 years ago [17]. Kodra is another name for Kodo millet. When compared to other millets, kodo millet has the greatest dietary fibre concentration and is a good meal for diabetes people. It has high protein content, a low fat content, a significant number of vitamins like folic acid (B9), niacin (B3), pyridoxine (B6), and certain minerals like calcium, iron, magnesium, potassium, zinc, etc. Gluten or wheat intolerance individuals utilize it because of the lack of gluten. Kodo millets also contain lecithin, which is beneficial to the neurological system. Consumption of kodo millet is beneficial to postmenopausal women suffering from excessive cholesterol or dyslipidemia, high blood pressure, and heart-related disorders [14]. Kodo millet can greatly reduce diabetes induced by alloxan in rats and is useful to treat general debility, haemorrhages, hepatopathy, and inflammation [28]. If you have beriberi, you can use the stem of the kodo millet plant as a poultice, and the concentrate of kodo roots can be used as a diuretic and galactogogue [29].

Proso millet (*Panicum miliaceum*)

Proso millet is an ancient crop that is an essential element of the human diet, notably in Asia, Australia, Europe, and the United States [30]. Chena is the colloquial name for proso millet, which has a shorter growth season [17]. It is abundant in calcium, dietary fiber, protein, and is gluten-free. In comparison to other available nuts, spices, and cereals, it is the most affordable source of manganese. It aids in the improvement of lipid profiles and the decrease of cholesterol. Proso millets are healthy for your bones and can help you against cardiovascular disease and breast cancer [14]. Proso millet carotenoids extract has exceptionally strong cellular antioxidant activity as compared to fruits and vegetables. The anti-proliferative efficacy of proso millets against human liver cancer cells is dose based. It contains around 65% phenolic compounds and is high in bioactive phytochemicals such as caffeic acid, chromogenic acid, frolic acid, and syringic acid, all of which are good for human health health [31]. In mice, the protein concentrate of proso millet greatly improves the glycemic response while reducing the insulin level [32]. Another research on diabetic rats proved the preventative nature of proso millet protein concentrate and indicated that it immediately improves D-glucosamine-induced liver damage in rats [33].

Nutritional Value of Millets

Millets are an important food source in dry and semi-arid regions of the world. They provide protein, unsaturated fats, minerals, nutrients, fibre, and polyphenols [34].

Millets as Nutri-Cereals: Proven Aspects

Millets are considered Nutri-cereals by the Millet Network of India (MNI) rather than coarse cereals because they are high in protein, which aids in the prevention of protein energy malnutrition (PEM), fiber, which aids in the prevention of cardiovascular disease and digestion problems, and gluten-free, which aids in the prevention of celiac disease. Millets also include minerals, vitamins, and antioxidants that aid in human body cleansing. Millets require very little irrigation and have a very short growth season. They can survive a broad variety of temperature variations and can thrive in hot and dry conditions without the need of fertilizer. Barnyard millet is high in antioxidants and aids in the regulation of body temperature and lipid profile. Barnyard and foxtail millet both mend body cells and help to prevent gallstones, breast cancer, and cardiovascular disease [35, 36, 37]. A previous study by [35] has demonstrated that foxtail millet enhanced hyperlipidemia rats' cardiovascular health by lowering triglyceride levels in plasma. Foxtail millet has anti-cancer properties. Moreover, earlier research indicated that foxtail millet derived phenolic extract substantially inhibits the growth of MDA-MB-231 breast cancer cells in a dose-dependent manner [31]. High dietary fiber and magnesium levels also help to reduce blood sugar levels, diabetes, and dyslipidemia. A high calcium mineral content aids in the treatment of bone and weight loss issues. Non-acid producing foods that is readily digestive, such as quinoa. Quinoa and foxtail millet are both high in protein, fiber, minerals, vitamins, phytochemicals, tannins,

and polyphenols, as well as lysine and carotenoid content. Furthermore, both have excellent properties that can help to improve both functional and nutritional food security [17].

A U.S. Patent was awarded in 2006 for the extraction techniques of anti-obesity compounds derived from millets that include hydroxyproline or N-acyl derivatives of hydroxyproline. This invention also covers isolated hydroxyproline or its N-acyl derivatives as a pharmaceutically active salt thereof or food and drink additives, food and drink, feeds, and feed additives for anti-obesity comprising the same substance [38].

[39] find out that Consumption of barnyard millets resulted in good satiation value, no food needs in between millet meals, and pleasant bowel movement, which healed their constipation condition. Millets lower triglycerides and improve blood sugar regulation, as well as the diastolic, lipid, and systolic profiles of millet diet participants.

As a result, diabetic patients should consume millet, particularly finger millet, foxtail millet, and sorghum [40]. Millets lower triglycerides and improve blood sugar regulation, as well as the diastolic, lipid, and systolic profiles of millet diet participants.

As a result, diabetic patients should consume millet, particularly finger millet, foxtail millet, and sorghum (Jali et al. 2012). Foxtail millets improve atherosclerosis by increasing lipid levels in diabetic kk- Ay mice [32]. The b-glucan (bG) isolated from finger millet has better antibiofilm activity against *Enterococcus faecalis, Lysinibacillus fusiformis, Proteus vulgaris,* and *Shigella sonnei* at very little minimum inhibitory concentrations (MICs), and bG is also an active inhibitor of a-amylase and a-glucosidase, which makes it an effective anti-diabetic. For anti-diabetic, anti-bacterial, and anti-oxidant actions, a minimum dosage of 100 lg/ml is recommended for biomedical applications [41].

Foxtail and barnyard millet restore the body's cells and tissues, inhibit gallstone development, cleanse the immune system, and help prevent cardiovascular disease and breast cancer in pre-menopausal women [5]. Quinoa eating on a daily basis modifies glucose response but has no impact on other cardiovascular disease risk indicators [16].

The administration of phenolic acid bound arabinoxylans (PA-AXs) derived from barnyard and foxtail millets induces minimal toxicity in muramic macrophage cells while increasing nitric oxide (minimal), reactive oxygen species (ROS), cytokine production, and immunological activation. PA-AXs or pure PAAX boosts millets' immune-stimulatory activity [42]. Foxtail millet proteins and prolamine peptide (MPP) are also used as anti-inflammatory and anti-carcinogenic agents, and bound polyphenol of inner shell (BPIC) extracted from the bran of foxtail millet is also a proven anti-tumor agent (Ji et al. 2020). Millets are anti-cancerous because Lunasin (a 43 amino acid peptide chain found in millets) inhibits histone acetyltransferases (HAT), which play a key role in cancer formation [43]. Finger millet polyphenols also reduce the cataract genesis in people by inhibiting its key cause aldolase reductase [44]. The seed coats of finger millets are anti-teratogenic, anti-diabetic, hypocholesterolemic, hypoglycemic, and nephroprotective in nature [45].

Millets are excellent bio-fortification agents, and their high iron content aids in the treatment of anaemia. Millets are a low-cost functional food that is high in calcium, which aids in the prevention of calcium deficiency in children, pregnant women, and breastfeeding mothers.

Millet starch hydrolysis

Millets contain around 55-60% starch and approximately 20-32% amylase in typical millets, however finger, pearl, foxtail, and proso millet have less and ranges between 34-35%. It has been found that the glycemic index and amylase content of millets are inversely proportional to each other [46]. The hypoglycaemic impact of millet starch is significantly influenced by its structural makeup. Millets have polygonal shapes, a few spherical starch granules, and a few pores. The pores on starch make it easier for the enzyme to start breaking down starch. Finger millet has the least pores and the least amount of enzymatic activity [47].

Effect of lipid on millet starch hydrolysis

The color of millets, which include a variety of important fatty acids including linoleic acid, palmitic acid, lauric acid, and oleic acid as well as starch, is an indication of how effectively the rate of starch hydrolysis has been reduced [48]. When cooked with lipids, millet starch hydrolysis is reduced [11].

Effect of protein on millet starch hydrolysis

Proteins like globulin, albumin, and glutenins surround starch granules in millets, acting as barriers to amylase, reducing the glycemic index as a result of the starch and protein collaborating to slow down the rate of starch hydrolysis [49].

In-vitro protein digestibility (IVPD) in millets

Plant protein (cereal, grains, legumes) is less digestible than animal protein for a variety of reasons, including tannins, protease inhibitors, the organisation of the protein, the protein's low solubility, and lower enzyme availability because of the cell wall or seed coat [50]. However, when soaking and dehulling are done ahead of cooking, the IVPD rises noticeably. After dehulling, soaking, and boiling, untreated millet has a lower IVPD than treated millet. While soaking also dramatically alters the IVPD of millets [51].

Health Benefits of Millets

Anti-cancerous effect of millet

Millets include phytosterols, b-glucans, antioxidants, and lignins that aid in protecting against cancers of the breast, prostate, colorectal, and many other types. Millets include dietary sitosterol (SIT), which may provide protection against chemically induced colon cancer. Rats with tumors are significantly reduced with SIT [52]. By producing short fatty acid chains of propionate, acetate, and butyrate, lignins are anti-cancerous and promote the proliferation of bifidobacteria. Butyrate works as a secondary chemopreventive agent by slowing the proliferation of cancerous lesion cells and preventing the development of malignant tumors [53].

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

Effect of millets on cardiovascular disease

Antioxidant qualities in millets assist to control dyslipidemia and so reduce the risk of coronary heart disease. Fiber, particularly dietary fiber, b-glucan, policosanols, and phytosterols have qualities that lower cholesterol, but apigenin and flavonoids have antioxidant effects [54].

Anti-tumorigenic effect against chronic myeloid leukemia k562 (CML) in finger millet

In the bone marrow, myeloid cells develop out of control in CML. numerous infectious disorders can be treated using finger millet as a nutritional grain. Because it contains a bifunctional alpha-amylase trypsin inhibitor known as RBI (ragi bifunctional inhibition), which works to simultaneously inhibit trypsin and alpha-amylase, finger millet seed extract has anti-proliferative effects on CML k562 [55].

Strategies to increase bioavailability of millet compounds

The nutritional value of grains may be increased by germination, hydrolysis enzyme, which causes biochemical change, the production of new components, and structural changes [11]. The germination of finger millet results in a gradual rise in sugar and a decline in starch as well as certain anti nutrients including phytate and tannins. Extended germination of 96 hours considerably raises the protein and IVPD levels [56].

One of the methods that enhance the bioavailability of millets is fermentation, and studies have shown that following fermentation, nutritional value, protein availability, and in vitro protein digestibility (IVPD) all rise as well. The nutritional profile of sorghum millet is improved by fermentation and germination, and these processes also significantly alter the chemical makeup of anti-nutritional agents [57]. In contrast to soaked, coarsely ground, dry heated, debranned millets, Hassan and his colleagues have shown that germinated millets exhibit an increase in protein and protein digestibility. The research also suggested that fermenting the germination-stage and coarsely ground millets significantly boosts the protein's quality and digestibility [58].

Millet Based Functional Foods

Due to consumer awareness, the food industry is creating new products, and the demand for cereal-based wholegrain foods is rising. This has led to the inclusion of underutilized crops in food items and provided consumers with a healthier alternative to traditional staple foods [34]. According to several studies, using millets as a bio-fortifier or functional food improves the food's effectiveness and efficacy. Millets are rapidly gaining acceptance due to the rising demand for gluten-free grains. Noodles, spaghetti, different cookies, extrude, injera, sourdough bread, non-sourdough bread, and fat replacer are merely a few of the gluten-free functional foods that food engineers and researchers have created that are currently being used by gluten-intolerant people [59]. Using sorghum, pearl millet, and soya, [13] produced cookies as ready-to-eat dietary supplements for school-age children. According to this study, two biscuits a day can contribute to an average 13% of a child's daily intake of fiber, but only contributing around 11, 16, and 8% of iron, magnesium, and zinc. The biscuits made with millet also had a long shelf life and good nutritional and sensory properties [59, 60]. Albino rats' blood sugar levels are likewise lowered by multi-millet biscuits, which also have a hypoglycemic impact [61] (Figure 1, Table 1).

One of the most popular fast foods eaten worldwide is noodle. When compared to branded noodles, millet blend composite flour developed noodles have a very low glycemic index but take more time to cook [62]. Millar investigations using more advanced methods and improved sensory, dietary, and

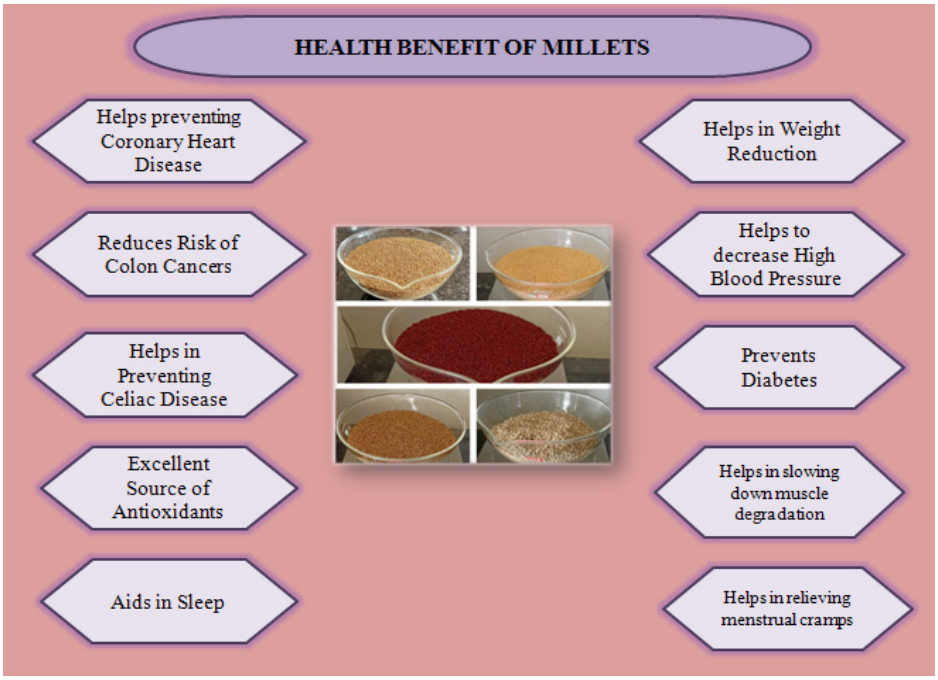

Figure 1. *Health Benefit of Millets.*

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

Table. 1. *Nutritive Value of Millets & its impact on Health.*

Millet Name	Scientific Name	Common Name	Phytonutrients	Protein(g/100g)	Total Fat (g/100g)	Dietary Fiber (g/100g)	CHO (g/100g)	Health Benefits
Pearl Millet	*Pennisetum glaucum*	Bajra, Bajri, Cumbu, Sajja.	Apigenin, Flavonoids, Lignin, myricetin	10.96	5.43	11.49	61.78	Anti-fungal, Anti-ulcerative, Prevents breast cancer and cardiac arrest.
Barnyard Millet	*Echinochloa spp.*	Banti, Sanwa, Oodalu, Khira	Luteolin, N-(p-coumaroyl), tricin, serotonin	6.20	2.20	-	65.55	Anti-diabetic, Anti-cancerous, Anti-rheumatic
Little Millet	*Panicum miliare*	Gajrao, Kutki, sava, sama,	Apigenin	8.92	2.55	6.39	65.55	Anti-diabetic, Anti-cancerous, Anti-rheumatic
Foxtail Millet	*Setarica italic*	Kakon, Kangani, Kangam, Rala	Apigenin, catechin, kempherol, quercetin	12.30	4.30	-	60.09	Detoxification of body, Anti-tumorigenic effect, curing infectious disease
Finger Millet	*Eleusine coracana*	Ragi, Mandua, Nachni, Marwa	Apigenin, catechin, leuteolin, myricetin, quercitin, tricin, kempherol, pyrocyanidin	7.16	1.92	11.18	66.82	Anti-tumorigenic effect, Anti-diabetic, Antioxidants, Antimicrobial
Quinoa Millet	*Chenopodium quinoa*	Quinoa	Lutein, zeaxanthin, β-carotene, flavonoids	13.11	5.50	14.66	53.65	Anti-cancerous, helps in constipation and celiac disease
Sorghum Millet	*Sorgum bicolor*	Cholam, Jola, Jowar, Rotla, Jondhana	Apigenidin, 5-glucoside, Leuteolinidin, 5-Methoxyluteolinidin, Apigenin	9.97	1.73	10.22	67.68	Anti-diabetic, Anti-cancerous, Anti-tumor, helps in controlling coronary heart disease
Kodo Millet	*Paspalum scrobiculatum*	Anika, Kodon, Kodua, Kodra	Apigenin, isovitexin, kempherol, leutolin, quercitin, vitexin	8.92	2.55	6.39	66.19	Anti-diabetic, Anti-cancerous, Anti-rheumatic
Proso Millet	*Panicun miliaceum*	Bachari, Baragu, Bari, Chena	Apigenin, myrecitin, kempherol	12.50	1.10	-	70.04	Anti-diabetic, Anti-cancerous, Anti-rheumatic

nutritional characteristics are also described [63]. Because of the relatively greater phenolic content (117%) and dietary fiber (76%) that have been found by employing a little concentration of proso millet's bran, gluten-free bread with millets bran may play a significant role in this research. However, it is not studied for its sensory or other nutritional properties [30]. The use of amaranth, quinoa, buckwheat, teff, and rye as a bread ingredient is also being investigated, and it has been discovered that high-phenol, dietary fibers, non-glutinous, and spongy bread with 70% acceptance has been produced [64].

Pasta made with pearl millet flour has very little cooking loss, a high protein content, iron, zinc, texture, and colour, as well as acceptable levels of hardness, chewiness, cohesiveness, gumminess, and springiness [65]. Fortification of functional foods with underutilized millet can raise the protein, carbohydrate, fat, and other nutritious food components by using composite finger and pearl millet flour [66]. Teff flour was also used to create gluten-free tagliatelle, a type of pasta, and individuals with celiac disease have successfully consumed foods that have an extremely low glycemic index (GI) [67]. Millets are similar to prebiotics in that they are calming, readily digested, and enhance the health of gut flora [21]. Many researchers have examined the prebiotic and probiotic properties of millets and have effectively shown that using millets as a prebiotic is acceptable and advantageous [68].

Conclusion

Underutilized millets are Nutri-cereals and must be implemented in the developing countries like India due to their high nutritional qualities, wealthy dietary fiber concentration and likewise effective in small as well a large scale supplements and best agent for fortification. Millets are nutrient-rich, gluten-free, alkaline, calming, and intestinally friendly, so those with constipation and those who are sensitive to wheat and gluten may eat them. Millets also include iron, calcium, manganese, magnesium, zinc, potassium, and phosphorus. Inflammations can be effectively treated using its cell and tissue maintenance effects. Millets include essential amino and fatty acids, flavonoids, phenolic compounds, and tannins. These are highly palatable and abundant in b-carotenoids and lecithin, allowing for the preparation of functional foods like pasta, noodles, biscuits, multigrain bread, etc. This aid in lowering cholesterol levels such as LDL, VLDL, triglycerides, etc., protecting us from hypertension. Additionally, millets lower the risk of developing heart disease and several cancers. All the aforementioned nutrients provide energy to body for the growth, maintenance, reproduction, and for performing all the body functions. Millets as high-energy nutritious food if utilized properly can combat malnutrition, obesity, diabetes, cardiovascular disease, protein-energy malnutrition, celiac disease, etc., as free from gluten. Millet is a crop that grows well in the dry season, is easy to digest, has a lot of lecithin, and is fantastic for boosting the sensory system. The vitamins A, B, D, and E, especially (B3) niacin, B6, and B9, as well as the minerals calcium, iron, and many other minerals, are all abundant in millets. By using millet properly, we can easily combat numerous pre- and post-transitional ailments and foster a healthy, disease-free environment in our nation. The creation of various functional foods, such as biscuits, bread pieces, pasta, noodles, and beverage powder, can potentially be a suitable substitute.

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

Conflict of Interest

There is no conflict of interest among authors in writing of this manuscript.

References

1. Verma S, Mishra S. Organoleptic properties and acceptability of ragi flour to prepare noodles. J pharmacogn phytochem. 2019;8(6):213-6.
2. Dubey P, Mishra S. Dietary implication of miracle cereal Finger Millet (Eleusine Coracana) and It's product development. Aegaeum. 2020;8(7):1306-16.
3. Bharali D, Mishra S, Mishra S, et al. Evaluation of Proximate Composition, Minerals and Micronutrient Contents of Finger Millet Herbi Dumpling. European J Nutr Food Saf. 2022;14(4):28-35.
4. Girish C, Meena RK, Mahima D, et al. Nutritional properties of minor millets: neglected cereals with potentials to combat malnutrition. Curr Sci. 2014;107(7):1109-11.
5. Gupta A, Sood S, Agrawal PK, et al. Under-utilized food crops of Himalayan region: Utilization and prospective. N Biotechnol. 2013:101-20.
6. Ambati K, Sucharitha KV. Millets-review on nutritional profiles and health benefits. Int J Recent Sci Res. 2019;10(7):33943-8.
7. Omram AR. The epidemiologic transition: a theory of the epidemiology of population change. Bull World Health Organ. 2001;79(2):161-70.
8. Thakur M, Tiwari P. Millets: the untapped and underutilized nutritious functional foods. Plant Arch. 2019;19(1):875-83.
9. Malathi B, Appaji C, Reddy GR, et al. Growth pattern of millets in India. Indian J Agric Res. 2016;50(4):382-6.
10. Michaelraj PS, Shanmugam A. A study on millets based cultivation and consumption in India. Int. J Marketing Financ Serv Manag Res. 2013;2(4):49-58.
11. Annor GA, Tyl C, Marcone M, et al. Why do millets have slower starch and protein digestibility than other cereals?. Trends Food Sci Technol. 2017;66:73-83.
12. Vinoth A, Ravindhran R. Biofortification in millets: a sustainable approach for nutritional security. Front Plant Sci. 2017;8:29.
13. Omoba OS, Taylor JR, de Kock HL. Sensory and nutritive profiles of biscuits from whole grain sorghum and pearl millet plus soya flour with and without sourdough fermentation. Int J Food Sci Technol. 2015;50(12):2554-61.
14. Rao BD, Ananthan R, Hariprasanna K, et al. Nutritional and health benefits of nuti cereals. Nutri Hub TBI, ICAR_ Indian Institute of Millets research (IIMR). 2018.
15. Jain RK, Bal S. Properties of pearl millet. J Agric Eng Res. 1997;66(2):85-91.
16. Lin HC, Sheu SY, Sheen LY, et al. The gastroprotective effect of the foxtail millet and adlay processing product against stress-induced gastric mucosal lesions in rats. J Tradit Complement Med. 2020;10(4):336-44.
17. Singh RB, Khan S, Chauhan AK, et al. Millets as functional food, a gift from Asia to Western World. InThe Role of Functional Food Security in Global Health. 2019;457-468.
18. Watanabe M. Antioxidative phenolic compounds from Japanese barnyard millet (Echinochloa utilis) grains. J Agric Food Chem. 1999;47(11):4500-5.
19. Usha B, Krishna Veni G, Muni Kumar D, et al. Partial characterization of α-amylase from germinating little millets (Panicum sumatrense). J Phytol. 2011;3(1).
20. Pradeep PM, Sreerama YN. Phenolic antioxidants of foxtail and little millet cultivars and their inhibitory effects on α-amylase and α-glucosidase activities. Food Chem. 2018;247:46-55.
21. Banerjee DP, Chowdhury R, Bhattacharya P. Sustainability of the probiotic lactobacillus casei in fortified indian milk cakes under different preservation conditions-effects of co-immobilization of L. casei and commercial prebiotic inulin (chicory based) and millet inulin. Int J Pharm. 2017;9(1):152-7.
22. Jacobsen SE. The worldwide potential for quinoa (Chenopodium quinoa Willd.). Food Rev Int. 2003;19(1-2):167-77.
23. Bhargava A, Shukla S, Ohri D. Chenopodium quinoa-an Indian perspective. Ind Crops Prod. 2006;23(1):73-87.
24. Li L, Lietz G, Bal W, et al. Effects of quinoa (Chenopodium quinoa Willd.) consumption on markers of CVD risk. Nutrient. 2018;10(6):777.
25. James LE. Quinoa (Chenopodium quinoa Willd.): composition, chemistry, nutritional, and functional properties. Adv Food Nutr. 2009;58:1-31.
26. Dykes L, Rooney LW. Sorghum and millet phenols and antioxidants. J Cereal Sci. 2006;44(3):236-51.
27. Chhikara N, Abdulahi B, Munezero C, et al. Exploring the nutritional and phytochemical potential of sorghum in food processing for food security. Nutr Food Sci. 2018;49(2):318-32.
28. Jain S, Bhatia G, Barik R, et al. Antidiabetic activity of Paspalum scrobiculatum Linn. in alloxan induced diabetic rats. J Ethnopharmacol. 2010;127(2):325-8.
29. Castillo ET, Siapno FE, Sambrana DG, et al. Grassland species with medicinal potentials. Res Inf Ser. 2005.
30. Mustac NC, Novotni D, Habus M, et al. Storage stability, micronisation, and application of nutrient-dense fraction of proso millet bran in gluten-free bread. J Cereal Sci. 2020;91:102864.
31. Zhang LZ, Liu RH. Phenolic and carotenoid profiles and antiproliferative activity of foxtail millet. Food Chem. 2015;174:495-501.

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

32. Choi YY, Osada K, Ito Y, et al. Effects of dietary protein of Korean foxtail millet on plasma adiponectin, HDL-cholesterol, and insulin levels in genetically type 2 diabetic mice. Biosci Biotechnol Biochem. 2005;69(1):31-7.
33. Ito K, Ozasa H, Noda Y, et al. Effects of free radical scavenger on acute liver injury induced by d-galactosamine and lipopolysaccharide in rats. Hepatol Res. 2008;38(2):194-201.
34. Alaunyte I, Stojceska V, Plunkett A, et al. Improving the quality of nutrient-rich Teff (Eragrostis tef) breads by combination of enzymes in straight dough and sourdough breadmaking. J Cereal Sci. 2012;55(1):22-30.
35. Lee SH, Chung IM, Cha YS, et al. Millet consumption decreased serum concentration of triglyceride and C-reactive protein but not oxidative status in hyperlipidemic rats. Nutr Res. 2010;30(4):290-6.
36. Xie M, Liu J, Tsao R, et al. Whole grain consumption for the prevention and treatment of breast cancer. Nutrients. 2019;11(8):1769.
37. Kumar A, Mazeed A, Kumar D, et al. Evaluation of yield potential and nutritional quality of various cultivars of barnyard millet (Echinochloa frumentacea L.) grown under subtropical India. Emergent Life Sci Res. 2020;6:54-9.
38. Kamiya T, Shirai A. U.S. Patent Application No. 10/549,157. 2006.
39. Ugare R, Chimmad B, Naik R, et al. Glycemic index and significance of barnyard millet (Echinochloa frumentacae) in type II diabetics. J Food Sci Technol. 2014;51:392-5.
40. Vedamanickam R, Anandan P, Bupesh G, et al. Study of millet and non-millet diet on diabetics and associated metabolic syndrome. Biomedicine. 2020;40(1):55-8.
41. Divya M, Karthikeyan S, Ravi C, et al. Isolation of β-glucan from Eleusine coracana and its antibiofilm, antidiabetic, antioxidant, and biocompatible activities. Microb Pathog. 2020;140:103955.
42. Srinivasan A, Ekambaram SP, Perumal SS, et al. Chemical characterization and immunostimulatory activity of phenolic acid bound arabinoxylans derived from foxtail and barnyard millets. J Food Biochem. 2020;44(2):e13116.
43. Park JH, Jeong JB, Lee JR, et al. Effect of Lunasin Extracted from Millet (Panicum miliaceum) on the Activity of Histone Acetyltransferases, yGCN5 and p/CAF. Korean J Plant Res. 2009;22(3):203-8.
44. Chethan S, Dharmesh SM, Malleshi NG. Inhibition of aldose reductase from cataracted eye lenses by finger millet (Eleusine coracana) polyphenols. Bioorg Med Chem. 2008;16(23):10085-90.
45. Shobana S, Harsha MR, Platel K, et al. Amelioration of hyperglycaemia and its associated complications by finger millet (Eleusine coracana L.) seed coat matter in streptozotocin-induced diabetic rats. Br J Nutr. 2010;104(12):1787-95.
46. Casey P, Lorenz K. Millet: functional and nutritional properties. Bak Dig.1977.
47. Kaur L, Singh J, McCarthy OJ, et al. Physico-chemical, rheological and structural properties of fractionated potato starches. J Food Eng. 2007;82(3):383-94.
48. Kawai K, Takato S, Sasaki T, et al. Complex formation, thermal properties, and in-vitro digestibility of gelatinized potato starch–fatty acid mixtures. Food Hydrocoll. 2012;27(1):228-34.
49. Hamaker BR, Bugusu BA. Overview: sorghum proteins and food quality. In Workshop on the proteins of sorghum and millets: enhancing nutritional and functional properties for Africa. 2003.
50. Becker PM, Yu P. What makes protein indigestible from tissue-related, cellular, and molecular aspects?. Mol Nutr Food Res. 2013;57(10):1695-707.
51. Pawar VD, Machewad GM. Processing of foxtail millet for improved nutrient availability. J Food Process Preserv. 2006;30(3):269-79.
52. Awad AB, Chen YC, Fink CS, et al. beta-Sitosterol inhibits HT-29 human colon cancer cell growth and alters membrane lipids. Anticancer Res. 1996;16(5A):2797-804.
53. Chen F, Cole P, Mi Z, et al. Corn and wheat-flour consumption and mortality from esophageal cancer in Shanxi, China. Int J Cancer.1993;53(6):902-6.
54. Kaur KD, Jha A, Sabikhi L, et al. Significance of coarse cereals in health and nutrition: a review. J Food Sci Technol. 2012;51:1429-41.
55. Chandra D, Chandra S, Sharma AK. Review of Finger millet (Eleusine coracana (L.) Gaertn): A power house of health benefiting nutrients. Food Sci. Hum. Wellness. 2016;5(3):149-55.
56. Mbithi-Mwikya S, Van Camp J, Yiru Y, et al. Nutrient and antinutrient changes in finger millet (Eleusine coracan) during sprouting. LWT - Food Sci Technol. 2000;33(1):9-14.
57. Chavan JK, Kadam SS, Beuchat LR. Nutritional improvement of cereals by fermentation. Crit Rev Food Sci Nutr.1989;28(5):349-400.
58. Hassan AB, Ahmed IA, Osman NM, et al. Effect of processing treatments followed by fermentation on protein content and digestibility of pearl millet (Pennisetum typhoideum) cultivars. Pak J Nutr. 2006;5(1):86-9.
59. Mancebo CM, Picon J, Gomez M. Effect of flour properties on the quality characteristics of gluten free sugar-snap cookies. LWT - Food Sci Technol. 2015;64(1):264-9.
60. Anju T, Sarita S. Suitability of foxtail millet (Setaria italica) and barnyard millet (Echinochloa frumentacea) for development of low glycemic index biscuits. Malays J Nutr. 2010;16(3):361-8.

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*

61. Subbulakshmi B, Malathi D. Formulation of multi millet cookies anf evaluate its hypoglycaemic effect in albino rats. J Crop Weed. 2017;13(3):112-6.

62. Vijayakumar TP, Mohankumar JB, Srinivasan T. Quality evaluation of noodles from millet flour blend incorporated composite flour.

63. Collar C. Impact of visco-metric profile of composite dough matrices on starch digestibility and firming and retrogradation kinetics of breads thereof: Additive and interactive effects of non-wheat flours. J Cereal Sci.2016;69:32-9.

64. Collar C, Angioloni A. Pseudocereals and teff in complex breadmaking matrices: Impact on lipid dynamics. J Cereal Sci. 2014;59(2):145-54.

65. Jalgaonkar K, Jha SK. Influence of particle size and blend composition on quality of wheat semolina-pearl millet pasta. J Cereal Sci. 2016;71:239-45.

66. Gull A, Prasad K, Kumar P. Optimization and functionality of millet supplemented pasta. Food Sci Technol. 2015;35:626-32.

67. Giuberti G, Gallo A, Fiorentini L, et al. In vitro starch digestibility and quality attributes of gluten free 'tagliatelle' prepared with teff flour and increasing levels of a new developed bean cultivar. Starch-Starke. 2016;68(3-4):374-8.

68. Kunchala R, Banerjee R, Mazumdar SD, et al. Characterization of potential probiotic bacteria isolated from sorghum and pearl millet of the semi-arid tropics. Afr. J. Biotechnol. 2016;15(16):613-21.

Citation: *Mishra S, Singh R. Potential Health-benefits of Millets "Nutri-Cereals"-A Review. J Prim Care Gen Pract. 2023;6(5):161*