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MILLETS AS A SUPERFOOD: NUTRITIONAL POTENTIAL OF UNDERRATED CEREALS

Dhanashree R. Kavhale
Department of Pharmaceutical Chemistry
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Email - dhanurk19@gmail.com

Nishikant A. Raut
Department of Pharmaceutical Sciences
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Yogeshwary M. Bhongade
Department of Pharmaceutical Sciences
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Shubham N. Gharat
Department of Pharmaceutical Sciences
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Abstract :

Millets are a significant food crop globally, particularly in developing countries, due to their pest and drought resistance properties. They have been cultivated in India and China since around 4500 BC, with India having the highest production. Millets are essential for energy in arid and semi-arid regions, often cultivated in borderline land with unfavourable agricultural conditions. They are often referred to as "superfoods" due to their high nutritional value. Superfoods, including grains like millets, oats, berries, lentils, quinoa, and chia seeds, are foods that contain bioactive phytochemicals or have abundant nutritional values providing additional health benefits. Millets are gluten-free, high in dietary fiber and antioxidants, and have low glycaemic index, helping to overcome health issues like diabetes, obesity, and lifestyle problems. Millets are known for their anti-oxidative and anti-inflammatory properties due to the variety of phytochemicals found in them. They are rich in proteins, which play a vital role in suppressing malnutrition and maintaining health and aging. The protein content of millets ranges from 8.5% to 12.5%, with Adlay millets having the highest and lowest amino acids.

Dietary fibres are a vital component of millets, with Adlay millets and Barnyard millets having 15% and 13.9% fiber content respectively. Consuming millet grains can alleviate the risk of cardiovascular diseases and promote wound healing. Studies have shown that consuming finger millets can decrease plasma glucose levels in diabetic rats and in Wistar rats.

Keywords: Superfood Millets, Nutritional potential, Underrated Cereals

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1. Introduction :

Millets are pronounced food crop worldwide with a notable economic impact on developing countries. Millets have advantage over other growing crops as they are pest and drought resistance grains. As millets are a conventional staple food of dry land regions of the

world. In India and China millet cultivation predates to around 4500 BC. The proof of processing and cultivation of millets around 3000 BCE was given by prehistorical archaeological authentications found at sanganakallu (Ballari, Karnataka)(1).

Highest millets production in taken by India in the world thereafter Nigeria and China. By the ancient times millets has set up its space in Indian Kitchen and thus, nowadays we find a wide-ranging array of indigenous varieties of numerous millets. In India bajra, ragi and sorghum are the top three millets which are widely cultivated.

To a large extent in Africa and Asia, millets (minor cereals) are the vital source of energy for the population living in arid and semi-arid part of the world. They are cultivated at a borderline land which have unfavourable agricultural conditions where the major cereals are unable to produce a significant yield (2,3). Millets also known as minor cereals grains are fall under the Poaceae family, which are often demoted to as superfoods.

To an increasing extent millets are considered as "poor man's food" in popular belief although that are packed with high nutritional values for healthy lifestyle (1). They must be remarketed as a "nutri-cereals" for the shake of promoting production and utilization of coarse millets and cereals. Recently, there has been a high prominence on 'superfoods' the term used for defining foods which are natural, containing high amount of nutrients, dense and balanced accompanied by rich source of diverse bioavailable compounds and antioxidants (1).

Superfoods are also defined as those food which either contains bioactive phytochemicals or have abundant nutritional values providing additional health benefits (4). This definition of superfoods enables to include grains such as millets, oats, berries, lentils, quinoa, chia seeds and various other in the same category (5). Millets are superfoods that can provide plausible solution for increased metabolic disorders along with various gut related diseases.

The United Nation declared 2023 as the International Year of Millets to spotlight the benefits of millets. Also, India has appealed for the year 2023 to be recognised as the "International Year of Millets" as year 2018 has already been recognised as National Year of Millets. The government of India has started awareness campaign called as "Millet Mindfulness" for making it as a movement of population (6). It is believed that the consumption of these foods leads to better health as it can help to regulate cholesterol and blood pressure and can help in preventing certain cancers and cardiovascular diseases (7). Millets were caused to became 'orphan crops' (less consumed and almost forgotten) because of push given by Green Revolution to the food security in the 1960s, its earliest authentication has been found in Indus Civilization. As millets are gluten free, high in dietary fibre and antioxidants along with low glycaemic index helps to overcome health issues like diabetes, obesity and lifestyle problems. Millets are known to have anti-oxidative and anti-inflammatory properties which are attributed by variety of phytochemicals found in them.

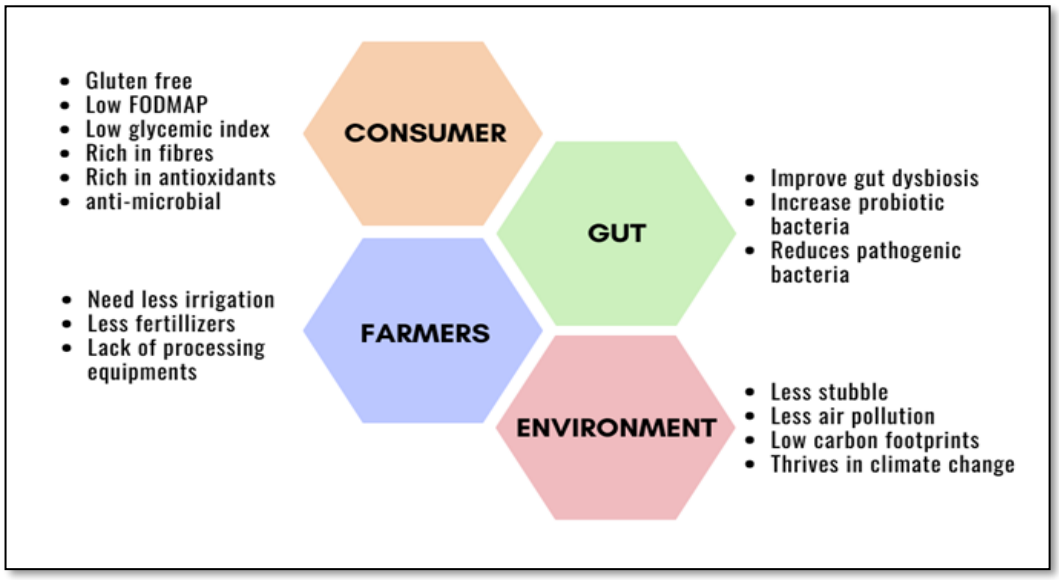

Figure 1: Advantages of millets to gut, farmers, consumers and the environment

1.1. Nutritional value of millets and its Composition :

Nowadays, superfood is a term used to indicate natural foods enriched with nutrient, containing balanced proportion of micro and macronutrients. Millet crops have been recognised as a part of high valued nourishing diet. Millet diets are necessary for normal growth, overall nutritional well-being and for controlling diabetes type 2 as these are the abundant source of fibrous materials (non starch polysaccharides) phytoconstituents, minerals and vitamins (8, 9).

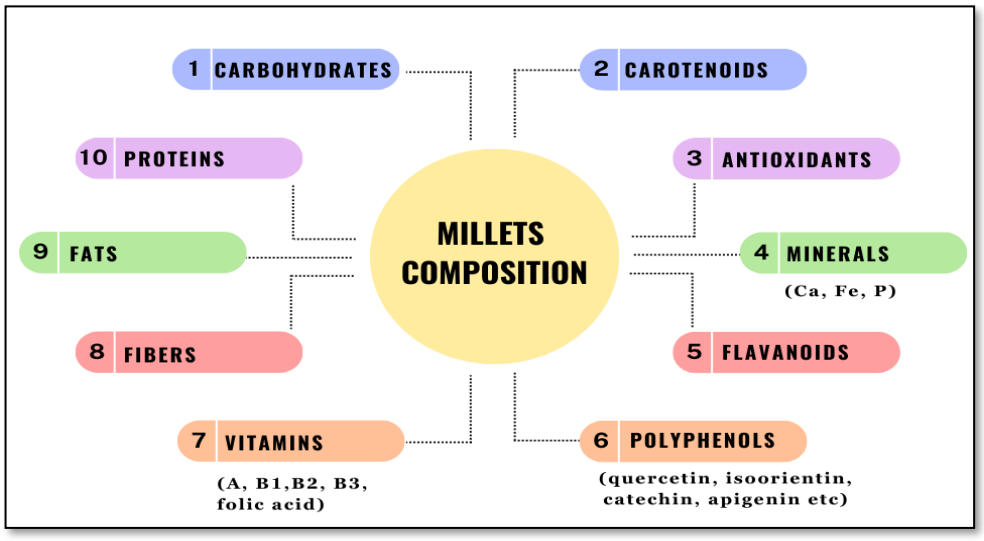

Figure 2: Composition of millets

Diverse bioactive phytochemicals are found in these cereals such as flavonoids, sterol, dietary Fiber, inulin, lignans, phenolics, beta-glucan, pigments and phytates on a large scale thus,

numerous health related benefits are accompanied by consumption of millets (10–12).Proteins which are found in millets play a vital role in the suppression of malnutrition (13). Foods which are made by utilizing millets are pronounced source of prebiotics and probiotics with major health assets (14).

Millet's rich in phenolics plays a major role in metabolic syndrome, maintaining health and aging (15). Phytates presents in millets have cholesterol lowering and anticancer property (16). For preventing the gall stone formation millets with high level of fibres are used. Due to presence of vitamin content and other bioactive compounds that helps to elevate antioxidant level and preserve calcium concentration of bones, the intake of millet predominantly enhances quality of bone (17).

1.1.1. Carbohydrates :

Primary component of millets are carbohydrates that accounts for more than 65% of its total content exception to this statement is, Japanese Barnyard millets which comprises of 56% of carbohydrates. The quality of protein and starch present in variety of millets is evaluated by Annor et al., (18). Content of carbohydrate in majority of superfood ranges between 65-77% which coincides with carbohydrates present in millets, deviations to this case are Adlay millets and finger millets which constitutes more that 80% of carbohydrate content (5).

1.1.2. Proteins :

The protein content of millets falls within a range of 8.5% to 12.5% with a special case of Adlay millets which is minor millets have protein content of about 6.7%. *Figure 4* depicts the essential amino acids that are present in various major and minor millets. Essential amino acids are found in least quantity in all the millets. However, there is diverse range of availability of amino acids (19). Among different varieties of millets Foxtail millet and Kodo millets have highest and lowest number of amino acids respectively. Foxtail millets have 3g/100g essential amino acids with leucine which alone contributes about 1g/100g of amino acids. Kodo millet are rich in lysine and phenylalanine in comparison to other millet varieties which has amino acid content of about 1.8g/100g (5).

1.1.3. Fats :

In millets fat content varies between 2 to 6% with more than 80% accounts for unsaturated fatty acids (20, 21). Little millet and finger millets has the highest and lowest fat contents respectively as given in graph below. According to research fat digestibility of traditional cereal is much lower as compared to millets (22). The consumption of oils from cereals and millets tackles health problems by lowering blood pressure, lowering blood cholesterol and prevention of cancer (20, 23, 24).

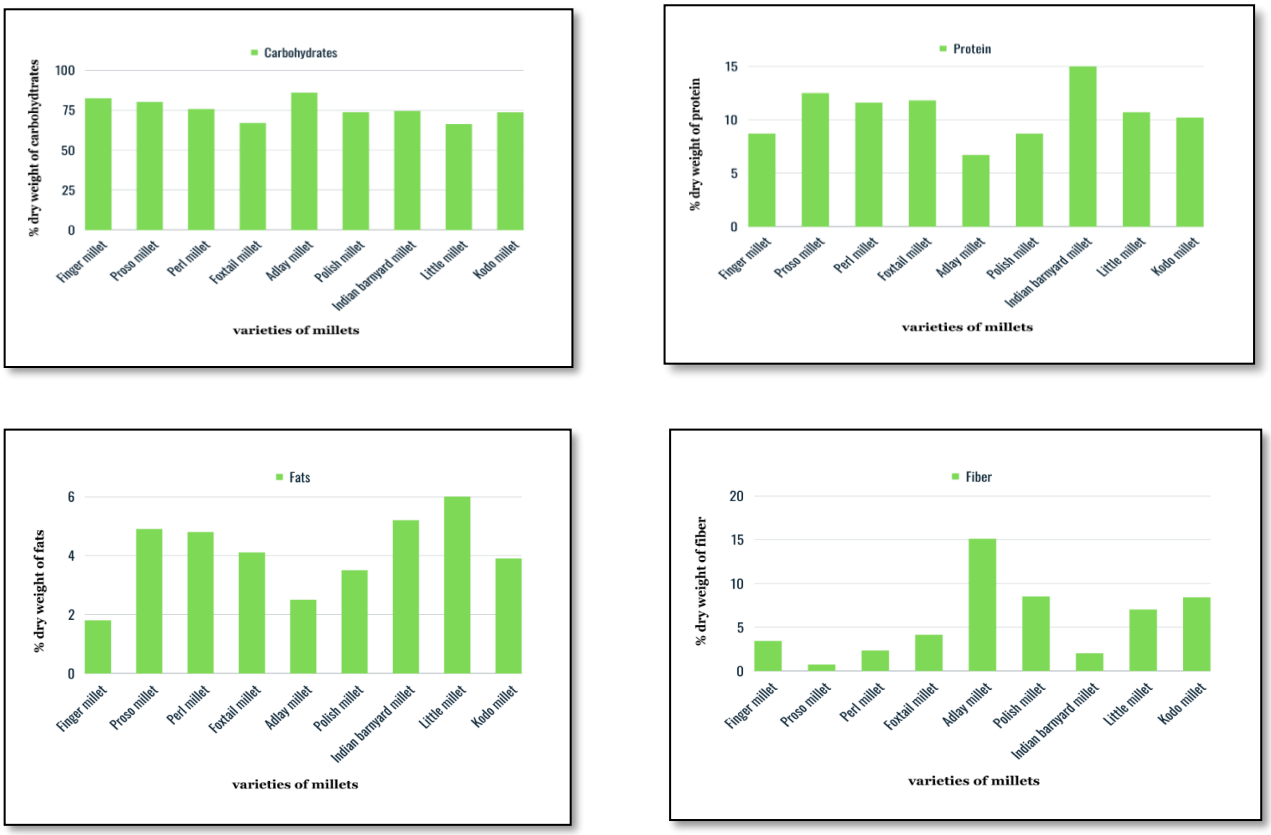

Figure 3: Graphical representation for nutritional composition of millets

1.1.4. Fibers :

Dietary fibres are the vital component of millets, the regular consumption of it provides variety of health benefits. The fiber content is significantly high in millet grains therefore intake of millet grains alleviates risk of cardiovascular diseases (25). Adlay millets and Barnyard millets have 15% and 13.9% fiber content respectively. Beyond this Polish millet and Kodo millet have high quantities of dietary fibres. For many health benefits it is necessary to consume dietary fibres in suitable amount.

Multiple studies provide report that consuming millet have a beneficial impact on health. Rajasekaran et al. (2004), pointed out that in diabetic rats that when they are fed with finger millets for a period of four weeks could promote wound healing process significantly and also regulate glucose level. In diabetic patients (non -insulin dependent) it is found that consuming finger millets decrease the plasma glucose level. In Wistar rats the similar hypoglycaemic effect was seen following consumption of Kodo millet and Finger millet grains (26, 27). Some peoples have gluten allergy, Celiac disease, wheat allergy, for those people millet serve as a option, as millets are free from gluten (28).

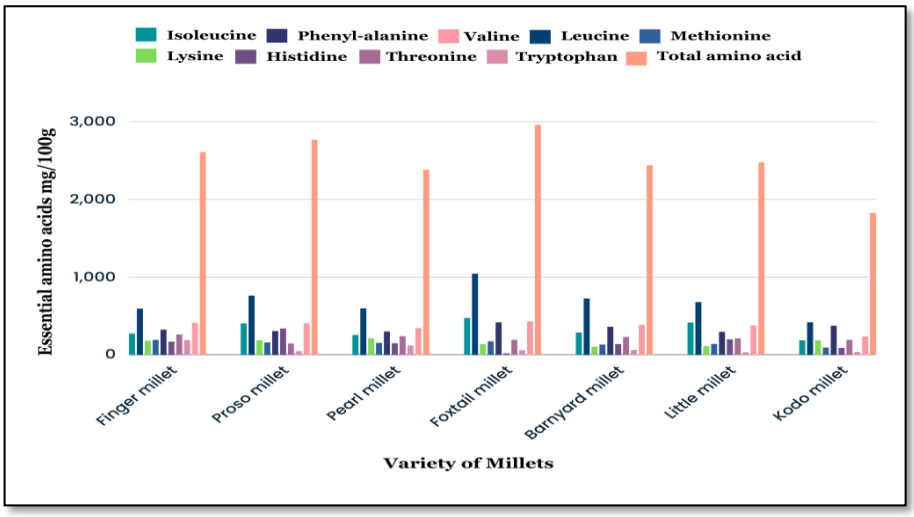

Figure 4: Essential amino acids in millets (mg/100g)

1.1.5 Minor nutrients and polyphenols

For large portion of the population in African and Asian countries millets are known as a staple food. Millets possess significant amount of polyphenols and micronutrients (minerals and vitamins) which provides calorie-rich and nutritious diet by contributing to several health benefits. Finger millets seed coat have notably high levels of calcium and its removal leads to calcium loss (29). Millets are found to have various vitamins like B vitamins comparable to variety of millets (Figure 5) (30).

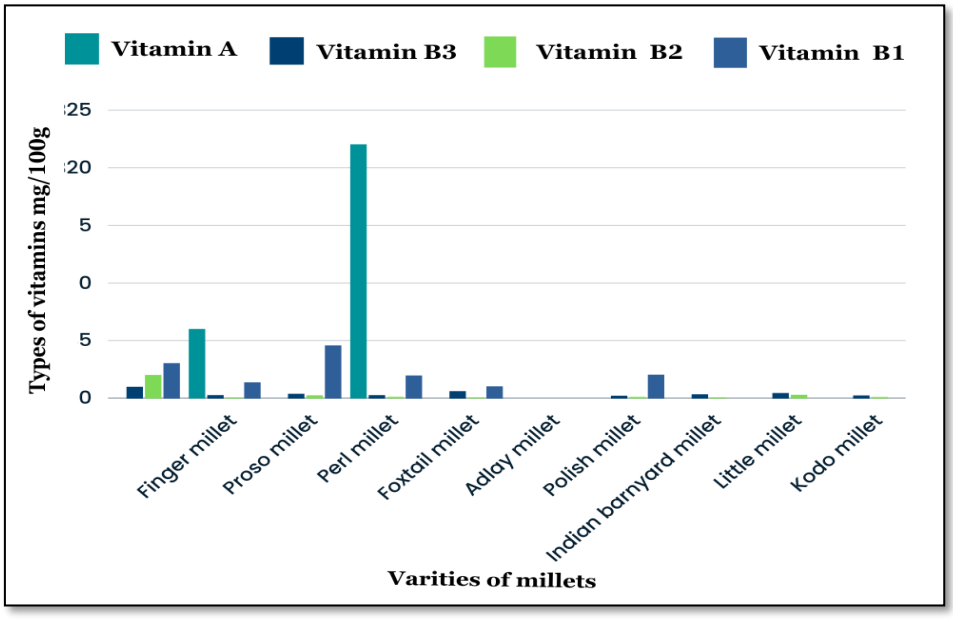

Figure 5: Vitamins present in millets (mg/100g)

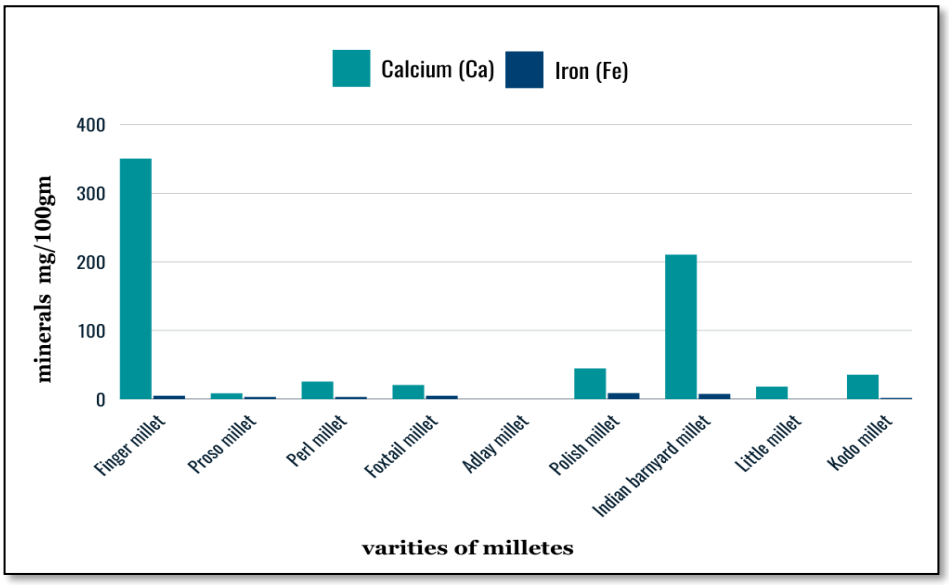

Figure 6: minerals (Calcium and Iron) present in millets (mg/100g)

1.2. Types of millets :

1.2.1. Finger Millet :

Finger millet is also known as Ragi. It is known to have highest amount of calcium, phosphate and iron along with other nutrients. Slow and easily digestibility of finger millet is because of its great antioxidant property like other phytochemicals. Finger millets helps to maintain health as it monitors blood cholesterol level, maintain bone strength, lower down the risk of anaemia and helps in losing weight (12). It is consumed in various forms such as pancakes, roti and porridge etc. These millets are also used to developed variety of bakery products. It has excellent malting property therefore it is widely accepted in the food processing (6).

1.2.2. Sorghum :

It is considered as an ancient cereal of India and it is widely accepted in different parts of India as a staple cereal. Sorghum has higher nutrient content and it also helps to tackle several health problems therefore it is regarded as a high-ranking in comparison to wheat and rice. It is described to have nutrient called policosanols present in Sorghum wax which helps to alleviate cholesterol level (1,19).

1.2.3. Pearl Millet :

Pearl millet is enriched with the high fibre content which aids in maintaining good digestion and for tackling obesity. It is a pronounced source of nutrients in comparison with majority of cereals such as wheat and rice which are consumed on daily basis. It helps for maintenance of bone health as it is abundant with the phosphorous (6). Pearl millet is packed

with high magnesium concentration thus it enables reducing chances of respiratory issues like asthma.

1.2.4. Proso Millet :

Like other variety of millets, Proso millet is also rich in minerals, proteins and fibres. Proso millet Protein present in Proso millet lower down the LDL and bad cholesterol level from the body and increases the HDL cholesterol level. Maintenance and repairing of neural health system aids by lecithin which is present in Proso millet in high amount (6). Due to its high antioxidant property, it reduces the incidence of cancer and variety of cardio vascular related diseases, along with that Proso millet is enriched with niacin and folic acids (B-complex vitamins).

Figure 7: Varieties of millets along with biological names

1.2.5. Foxtail millet

Foxtail millets grains are comparably coarse than other cereals which shows digestibility of about 79% and remaining portion of indigestible grains are also have high content of fibre. It also has relevant amount of minerals proteins and vitamins. Because of digestibility property it reduces the risk of several degenerative diseases. As it contains high level of magnesium concentration thus known as healthy heart food. Foxtail millet is known as excellent source of nutrition which is highly used for preparation of daily meals such as noodles, pancakes, cereal porridge, soups along with alcoholic beverages (6,19).

1.2.6. Barnyard millet :

The nutritional value of barnyard millet is considered to have higher than other major and minor cereals. It helps in maintaining blood sugar level as the high level of crude fibre content present in barnyard millet releases sugar in blood. In comparison to other cereal grains, it is rich in carotenoids and polyphenols. Among all the nutrients present in the barnyard millet it is abundant source of iron which accounts about 15.6-18.6mg/100g that makes millet as a leading food for the anaemic patients and other disorders (3).

1.2.7. Kodo Millet :

High nutrient present in Kodo millet which can be used for substituting rice and used for weight loss. Kodo is enriched source of bioactive compounds along with the antioxidants and helps for dealing with diverse lifestyle disorders (31). It is also advantageous for the nervous system functioning attributed by presence of lecithin.

1.2.8. Brown top millet :

It helps in prevention of gastric problems, lowering acidity in adults and enhancing metabolic activities, which in turn contains a magnificent amount of phosphorous helps in reducing weight and act as a probiotic for gut. Usually consumed in the form of porridge (31, 32).

Millets can be area of focus as it raise the economy of state as well as country by boosting the food processing industry. They possess adequate potential to relieve from various leading environmental disasters and lifestyle disorders.

1.3. Millets as a medicine :

As the millets are recognised as superfood which are protective against the various metabolic disorders, large number of protective polyphenols such as quercetin, isoorientin, catechin, apigenin, hydroxycinnamic acid, luteolin and orientin are present in them. These polyphenols show anti-inflammatory activity and antioxidant activity with free radical scavenging action. In comparison with rice and wheat, millets are good source of major nutrients like proteins and energy along with minor nutrients such as vitamins which includes vitamin A, B, D, E, and B complex, iron, zinc and antioxidants (6). Millets have high protein content (10–12.3 g/100 g), calcium (10–410 mg), iron (0.5–19.0 mg) and fat (1% to 5%), if compared to wheat and rice (Figure 6) (33).

Proso millets, foxtail millet and pearl millets having highest phenolic acids. Finger millets are rich source of flavonoids, and seed coat of finger millets shows potent antifungal and antimicrobial activity (33). Hydroxycinnamic acid commonly ferulic acid which is present in millets has potential antioxidant properties (34).

Millets are packed with phytates, phenols and tannins that helps in shielding a cell against potential diseases such as high cholesterol, diabetes and high blood pressure. Additionally, finger millet is a very good source of vitamin B complex, which play a crucial

role from healthy cell division to brain functioning. As millets being a member of Poaceae family, are frequently refers as "coarse cereals" and also been renamed as "nutri-cereals".

These coarse grains have been given the stature of "Shree Anna" due to its supplementary advantage of being gut- friendly (35, 36).

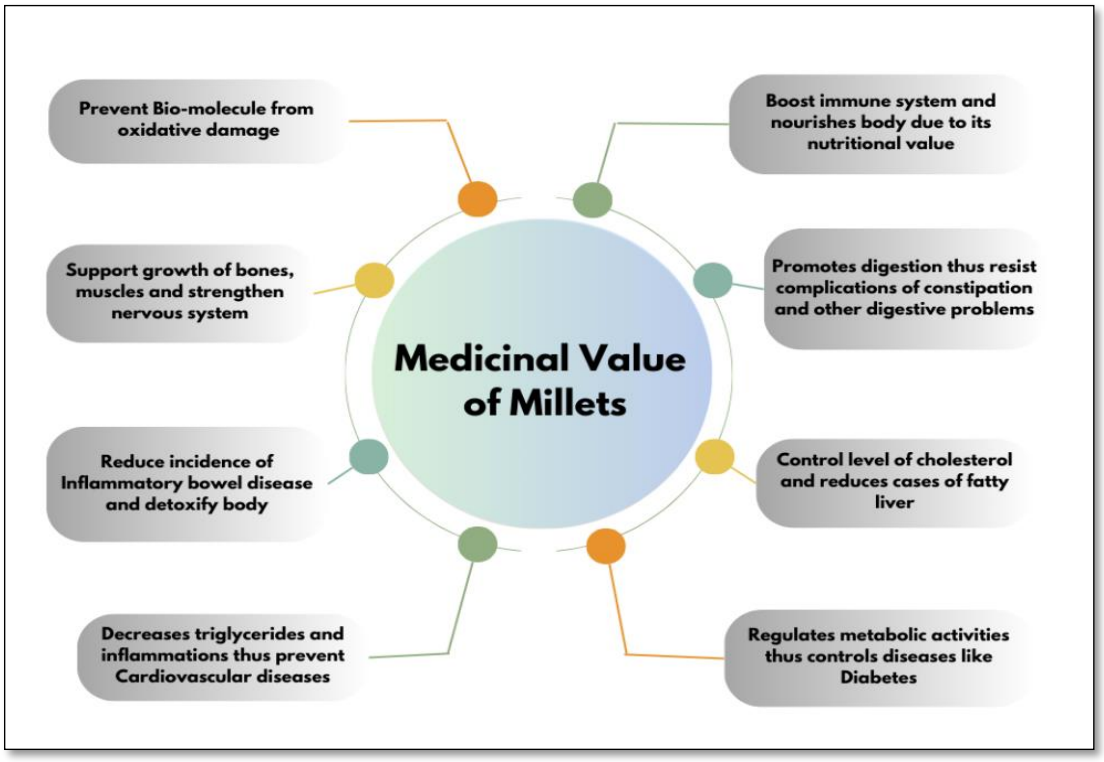

Figure 8: Medicinal value of millets

According to Ayurveda foxtail millets are depicted as Kudhnya, Trundhanya or Kshudradhanya possessing properties like sweet with astringent taste. As per Ayurveda it conciliates khapha and Pitta Dosha and elevates Vatadosha. These millets have great importance in Ayurveda. Rishimunis used to consume millets because it has digestibility apart from nutritional food value. Therefore, in Nighantu Aadarsha it is termed as Munidhanya (19). Millets are described as non-allergenic, nutrition rich and gluten free grains (19).

1.4. Millets with potential immunity boosting benefits :

The immune system should be vigilant for monitoring the risk signals or attack from foreign bodies. Immune system cells must be able to differentiate between self from non-self and moreover separate out the non-self-molecules which are dangerous as received from pathogens and also foreign substances which are obtained from foods (37).Variety of immunological effects such as vitamin E which acts as both inhibitor of protein kinase C activity, antioxidant and enzyme interaction and transportation of proteins can be exhibited by the single nutrients (38).

Unlike cereals (wheat and rice) millets are nutritionally superior for energy and carbohydrates, and are good sources of diverse nutrients like vitamins, protein, minerals, high

dietary fibre, micronutrients and antioxidants.

Proso millet is significantly richer in essential amino acids (methionine, leucine, isoleucine,) by increasing its protein value than wheat protein. Pearl millet is remarkably the richest source of Fe (6.4 mg/100 g) among variety of cereals (39). It contains antioxidants, minerals, resistant starch along with soluble and insoluble dietary fibres. Finger millet (ragi) grains contain some vitamins and vital minerals such as phosphorus (P) and calcium (Ca) (39). Millets perform crucial role in our body for uplifting our immune response towards pathogens by utilizing the abundant source of minerals and vitamins present in them. Immunity safeguards the life, by mediating humoral immune response and cellular response. The body regulates the formation of T lymphocytes, cytokines and antibodies thereby promoting systemic immune processes.

Coronavirus disease-2019 (COVID-19) is one of the contagious diseases which is defined as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (40).

Long -lasting immune boosting effect can be acquired by consuming diverse nutrients through natural sources. These natural sources are fruits, vegetables, cereals, spices, herbs, nuts, oilseeds and some superfoods like chlorella and spirulina and millets is one of them. Consumption of millets as a superfood is widely used during the outburst of Covid-19 which is packed by variety of the nutrients which helps in boosting the immune system (41).

The richness of minerals and vitamins in millets perform a key role for improving level of immune response towards foreign particles or pathogens. Although, there are no direct result which proves the statement of boosting immunity by millets are available but many researchers and scientists' advices the consumption of precise portion of vitamins, antioxidants and minerals through millets would enhances the performance of the immune system (42).

1.5. Pharmacological role of millets :

In recent years grains of millets has made remarkable advances. Millets known to have biological activity of plausible pharmaceutical value by producing variety of compounds. Extensive amount of interest in pharmaceutical industry has generated due to the crude extracts and isolated compounds from the diverse millet grains since years. This review emphasises on several pharmacological activities shown by varieties of millets such as antioxidant, anti-inflammatory, anticancer, antimicrobial and antidiabetic activity. cover areas related to antimicrobial, anti-inflammatory, antidiabetic, anticancer, and antioxidant activity of varieties of millets that claims authentication.

1.5.1. Antimicrobial and anti-inflammatory activity :

Millet grains show broad scale of biological properties since it possesses various secondary metabolites. Antibacterial and antifungal activities are exhibited due to presence of

bioactive secondary metabolites like flavonoid and phenolic compounds in variety of millet (43).

Antimicrobial activities of phenolic compounds of finger millet grains are full of phenolic compounds which exhibits antimicrobial activities and can be used for efficacious pharmaceutical alternative for treatment of fungal as well as bacterial infections (44). Phenolic seed coat extract of finger millet shows loss of fungal functionality and the mechanism for the same is studied by Siwela et al., (45). According to study, phenolic extract of finger millets shows free radical oxidation of microbial membrane and inactivate the enzymatic activity of proteins in fungi.

1.5.2. Anti diabetic activity :

Millet varieties rich in bioactive compound shows antidiabetic activity due to their potential for supressing digestive enzymes like α-glucosidase and α-amylase (27). Finger millet-based food lowers glycaemic effect attributed by decreased absorption and starch digestibility thus they are evaluated for their antinutritional factors. Antidiabetic potential of these grains due to active biomolecule via inhibition of starch- digestive enzymes along with regulation of glucose-induced oxidative stress. Anti-lipidemic and antihyperglycemic activities possesses in aqueous extract of *S. italica* (Foxtail millet) seeds against streptozotocin induced diabetic rats (46). Shobana et, al. (47) proved various activities of finger millet against diabetes induced rats such as nephroprotective, hypocholesterolemic, anti-cataractogenic and hypoglycemic activity. Antidiabetic activity of ethanolic and aqueous extract of Kodo millet (*P. scrobiculatum*) against alloxan induced diabetic rats was confirmed by Jain et al. (48).

1.5.1. Antioxidant activity :

The remarkable antioxidant activity of different millet grains like Finger millet, Kodo millet, Foxtail millet, little millet, Great millet, Barnyard millet and their wide varieties were studied in terms of Ferric reducing antioxidant potential along with DPPH reduction capacity (49–51). Presence of Flavonoids and Phenolics in millet grains have potential of chelation of metal ions, prevent free radical formation and free radical induced cell damage thus serves as a antioxidant by improving endogenous system (32). Phenolic content and antioxidant ability of millet grains helps in protection of cell against metabolic syndrome and act as an anti-aging agent (15). Pradeep et, al. (52) have studied the effect of nutraceuticals processing and antioxidant activity of little millets (*P. sumatrense*) and declared that roasted samples remarkably increased the nutraceutical properties in terms of free radical scavenging ability and enhanced phenolic content.

Conclusion :

Millets are an excellent source of different micronutrients and bioactive compounds which serves as diverse health functions. Although millets are highly underrated food and believed as a poor man's food but due to its plausible medicinal and nutritional values lead it

to be recognised as a superfood. In this review we have spotlighted the pharmacological potential of the variety of millets along with their nutritional aspects. Further the presence of phenolic content and flavonoids shows antimicrobial activity along with antioxidant activity. Ability of millets to thrive in less water and in marginal lands makes them beneficial for the farmers, consumer along with the environment. Thus, it could be helpful for the world to nurture millets for food security as well as superfood in upcoming years.

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