IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MODIFIERS OF IRON ABSORPTION IN SOUTH INDIAN IRON RICH MILLET DIET

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Abstract :

Iron is an essential mineral that the body needs to produce haemoglobin, which transports oxygen from the lungs to all of the body's tissues. Iron is primarily stored as ferritin in the liver, spleen, and bone marrow. Foxtail millet (korra), finger millet (ragi/ragulu), barnyard millet (odalu), little millet (sama), and kodo millet are the staple millets of South India. In addition to these 5, South Indians also consume pearl and jowar millet. Millets Contain modifiers (Inhibitors and Enhancers) of iron absorption. By consuming Millets with appropriate cooking techniques and food combinations , bioavailability of iron can be increased .

Introduction :

An important mineral the body needs to make hemoglobin, a substance in the body that carries oxygen from the lungs to tissues throught out the body.

•The total body iron content of normal adults is 4.3 and 2.3gms in men and women respectively

•Iron is primarily stored in the liver,spleen,and bone marrow in the form of ferritin

— Dietary iron has two main forms: heme and nonheme [1] . Only nonheme iron can be found in plants and iron-fortified meals, whereas both heme and nonheme iron can be found in meat, seafood, and poultry[2]. In western populations, heme iron, which is formed when iron combines with protoporphyrin IX, accounts for 10% to 15% of total iron intake [3-5]

Why do we need iron _

*Iron is a mineral found in every cell in the body

*It is vital for both physical health and mental well being

Source of iron :

Food

*Lean meat and seafood are the best sources of heme iron in the diet [6]. Nonheme iron is found in nuts, beans, vegetables, and fortified grain products. Bread, cereal, and other grain products provide approximately half of the dietary iron in the United States [2,3,5].

*Breast milk contains highly bioavailable iron, but not in sufficient quantities to meet the needs of infants aged 4 to 6 months [2,7].

*Other dietary factors have less of an impact on the bioavailability of heme than nonheme iron, and heme iron has a better bioavailability than nonheme iron [3,4].

*The bioavailability of iron ranges from 5% to 12% in vegetarian diets and between 14% and 18% in mixed diets that contain significant amounts of meat, seafood, and vitamin C (ascorbic acid, which increases the bioavailability of nonheme iron) [2,4].

_ In Table 1, a number of iron-rich foods are included. Because they include substances that prevent iron from being absorbed, such as polyphenols, several plant-based foods that are good sources of iron, such spinach, have low iron bioavailability [8,9].

Table 1: Iron Content of Selected Foods [10]

Food	**Milligrams per serving**	**Percent DV***
Breakfast cereals, fortified with 100% of the DV for iron, 1 serving	18	100
Oysters, eastern, cooked with moist heat, 3 ounces	8	44
White beans, canned, 1 cup	8	44
Beef liver, pan fried, 3 ounces	5	28
Lentils, boiled and drained, ½ cup	3	17
Spinach, boiled and drained, ½ cup	3	17

Tofu, firm, ½ cup	3	17
Chocolate, dark, 45%–69% cacao solids, 1 ounce	2	11
Kidney beans, canned, ½ cup	2	11
Sardines, Atlantic, canned in oil, drained solids with bone, 3 ounces	2	11
Chickpeas, boiled and drained, ½ cup	2	11
Tomatoes, canned, stewed, ½ cup	2	11
Beef, braised bottom round, trimmed to 1/8" fat, 3 ounces	2	11
Potato, baked, flesh and skin, 1 medium potato	2	11
Cashew nuts, oil roasted, 1 ounce (18 nuts)	2	11
Green peas, boiled, ½ cup	1	6
Chicken, roasted, meat and skin, 3 ounces	1	6
Rice, white, long grain, enriched, parboiled, drained, ½ cup	1	6
Bread, whole wheat, 1 slice	1	6
Bread, white, 1 slice	1	6
Raisins, seedless, ¼ cup	1	6
Spaghetti, whole wheat, cooked, 1 cup	1	6
Tuna, light, canned in water, 3 ounces	1	6
Turkey, roasted, breast meat and skin, 3 ounces	1	6
Nuts, pistachio, dry roasted, 1 ounce (49 nuts)	1	6
Broccoli, boiled and drained, ½ cup	1	6
Egg, hard boiled, 1 large	1	6

*DV stands for Daily Value. The U.S. Food and Drug Administration (FDA) created DVs to assist customers in comparing the nutritional content of foods and dietary supplements in the context of a complete diet. For adults and kids who are 4 years old and older, the DV for iron is 18 mg [11]. The FDA requires iron content to be listed on food labels. Foods with 20% or more DV are considered high sources of a nutrient, but foods with lower percentages of DV also contribute to a healthy diet.

Daily requirements of iron diet :*Dietary Reference Intakes (DRIs), created by the Food and Nutrition Board (FNB) of the Institute of Medicine (IOM) of the National Academies, offer intake guidelines for iron and other minerals (formerly National Academy of Sciences) [5].

According to age and gender, these variables include :

• Recommended Dietary Allowance (RDA) : It is frequently used to create individualised diet plans that are nutritionally adequate for people. The average daily intake is sufficient to meet the nutrient needs of nearly all healthy people (97%–98%).

• Adequate Intake (AI): When there is not enough data to calculate an RDA, intake at this level is presumed to guarantee nutritional adequacy.

•Estimated Average Requirement (EAR): It is typically used to evaluate the nutrient intakes of groups of people and to develop diets that are nutritionally appropriate for them. However, it can also be used to evaluate the nutrient intakes of individuals. The average daily consumption is thought to meet the needs of 50% of healthy individuals.

•Tolerable Upper Intake Level (UL): The recommended daily intake is unlikely to have a negative impact on health.

Table 2_ lists the current iron RDAs for nonvegetarians. Vegetarian RDAs are 1.8 times greater than those for meat eaters. This is due to the fact that heme iron from meat is more accessible than nonheme iron from plant-based meals, and that nonheme iron is more readily absorbed when consumed with meat, poultry, and seafood [5].

Table 2: Recommended Dietary Allowances (RDAs) for Iron [5]

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months	0.27mg*	0.27mg*		
7-12 years	11mg	11mg		
1-3years	7mg	7mg		
4-8 years	10mg	10mg		
9-13years	8mg	8mg		
14-18years	11mg	15mg		
19-50years	8mg	18mg	27mg	10mg
51+years	8mg	8mg	27mg	9mg

Iron deficiency : In the United States, an iron deficiency is not unusual, particularly in young children, women who are fertile, and pregnant women. People with iron deficiency usually have other nutrient deficiencies because it is associated with poor diet, malabsorptive disorders, and blood loss [2]. According to the World Health Organization (WHO), iron deficiency is thought to be the cause of over half of the 1.62 billion instances of that exist worldwide [20]. Iron deficiency is frequently caused by enteropathies and blood loss brought on by gastrointestinal parasites in poor nations [2].

Table 3-

	Systemic iron overload	Iron misdistribution/local iron deposition*
Genetic	• Hereditary hemochromatosis (HFE-, TfR2-, HJV-, HAMP-, or FPN-related) • Ferroprotein disease • Aceruloplasminemia • Atransferrinemia • DMT-1 deficiency • Private/sporadic iron overload diseases (e.g. H-ferritin related iron overload) • Hereditary iron-loading anaemias due to inefficient erythropoiesis	•Congenital sideroblastic anemias • Friederich ataxia • Neuroferritinopathy
Acquired	• Post-transfusion • Parenteral • Oral • Alloimmune neonatal hemochromatosis	• Chronic liver diseases • Neurodegenerative disorders (including NBIA unrelated to iron-genes) • Anemia of chronic diseases

Iron overload diseases:

*sideroblastic anaemias

*thalassemia's

*sickle cell disease

*rare anaemias

Kinetics of iron :

Absorption-

Iron is absorbed mainly from the small intestine, predominantly in the duodenum and upper jejunum.

Heme and non-heme iron are the two varieties of dietary iron that are absorbable.

- Heme iron is the most easily absorbed form of iron (15% to 35%) and accounts for 10% or more of the total iron we absorb. Heme iron is produced from hemoglobin and myoglobin of animal dietary sources (meat, fish, poultry).
- Non-heme iron, which comes from plants and meals with added iron, is less readily absorbed [27].

Some dietary components inhibit or enhance the duodenal pH-dependent process of iron absorption[27].

→ Phytate, a substance present in diets based on plants and showing a dose-dependent effect on iron absorption, is one of the inhibitors of iron absorption. Black and herbal tea, coffee, wine, legumes, grains, fruit, and vegetables all contain polyphenols, which have been shown to prevent the absorption of iron. Calcium inhibits both heme and non-heme iron at the point of first uptake into enterocytes, in contrast to other inhibitors such polyphenols and phytates that solely impede non-heme iron absorption. Human iron absorption has been demonstrated to be inhibited by animal proteins such casein, whey, egg whites, and proteins from plants (soy protein). Oxalic acid, which is present in spinach, chard, beans, and almonds, binds to iron and prevents it from being absorbed.

Distribution :

Total body iron

3500 to 3700 mg in a 70kg man

2000 to 2500 mg in female.

Body iron content of an adult is 3-5 g (~ 45 mg / kg woman, ~ 55 mg / kg for men). The majority of the body's iron (60–70%) is contained in the hemoglobin of circulating erythrocytes. Hepatocytes and RES macrophages store ferritin and hemosiderin, which make up about 20–30% of the body's total iron supply. Although only about 3 mg of iron is bound to transferrin, every day, about 20 mg of iron passes through the plasma transferrin compartment. When there is an excess of iron, NTBI can manifest in the plasma. The bone marrow is the main consumer of circulating iron. Every day, 200 billion new erythrocytes are formed, and each one contains 18–20 mg of iron, most of which is recycled. Iron loss is made up for by the 1-2 mg of iron that healthy persons absorb each day. NTBI - non-transferin bound iron; RBCs - red blood cells; Tf – transferrin[30].

Iron transport and storage : The primary iron transport protein is called transferrin (transports iron through blood). The Fe2+ transported by ferroprotein needs to be converted to Fe3+ because this is the form of iron that binds to transferrin. Hephaestin and ceruloplasmin are two copper-containing proteins that catalyse this oxidation of Fe2+. While ceruloplasmin is the main copper transport protein in blood, hephaestin is present in the membrane of enterocytes. The main protein that carries out this function in a coupled (necessarily simultaneous) manner with transport via ferroprotein is hephaestin. This indicates that for the Fe2+ to be transported through ferroportin, it must be oxidised. Evidence suggests that when iron status is low, ceruloplasmin is involved in oxidising Fe2+. Fe3+ is oxidised and then binds to transferrin before being delivered to a tissue cell with a transferrin receptor. As shown below, transferrin binds to the transferrin receptor and is then endocytosed.[66]

As a result, because red blood cells only live for 120 days, iron recycling is important. The liver, spleen, and bone marrow break down red blood cells, and the iron can be used for the same things as previously mentioned: cellular use, storage, or transportation to another tissue on transferrin. The creation of heme and ultimately red blood cells will use the majority of this iron.[66]

Among minerals, iron is special in that our body can only excrete a small amount of it. Hepcidin, a hormone, thus controls absorption. The liver has an iron sensor, which signals the release of hepcidin when iron levels rise. Ferroportin is degraded by hepcidin. As a result, the iron cannot be moved into circulation.[66]

The enterocyte, which eventually removes off and is excreted in faeces, is now holding the iron captive. As a result, hepcidin reduces the absorption of iron.

Modifiers of iron absorption in south Indian iron rich millet diet

The term "millets" refers to a wide range of annual cereal crops that are known for their tendency to yield tiny seeds. Several grasses that are used as food, fodder, and biofuel are included in this group, including foxtail millet (Setaria italica), finger millet (Elucine coracana), pearl millet (Pennisetum glaucum), proso millet (Panicum miliaceum), kodo millet (Paspalum scorbiculatum), barnyard millet (Echinocloa sp,)etc. [54]

A diverse collection of small-seeded grasses known as millets are widely cultivated as cereal grains for use as fodder and human sustenance all over the world. The majority of the species that are commonly referred to as millets are members of the Paniceae tribe, but some millets are also members of other taxa.[31]

TYPES OF IRON RICH MILLETS-

1.Barnyard millet(sanwa)

2. sorghum millet (jowar)

3.pearl millet (bajra)

4.kodo millet

5. finger millet (Ragi, Nachni)

6.little millet (kutki)

7.foxtail millet (korra)

8.proso millet (chena)

Barnyard millet : Echinochloa spp., also known as barnyard millet, is one of Asia's most important minor millet crops. The two most widely grown and well-known Echinochloa spices are Echinochloa esculenta (barnyard millet, which has a Japanese origin) and Echinochloa frumentacea (Indian based barnyard millet).Barnyard millet is highly adaptable despite having a brief life cycle, and current research has demonstrated that this crop is a functional food due to its high nutritional and antioxidant value (see table 4 for details)[32].

Table 4; [32]. **source-** Barnyard millet: The underutilized nutraceutical minor millet crop Anjali Singh, Munnangi Bharath, Apurva Kotiyal, Lipakshi Rana and Devanshi Rajpa

Domain	**Eukaryotes**
Kingdom	plantae
Phylum	spermatophyte
Sub phylum	Angiospermae
class	monocotyledonae
order	cyperales
family	poaceae
genus	echinochloa
species	Echinochloa species

- The grains of barnyard millet are used as food and can be cooked like rice to be consumed. They can also be used as a functional food for those with atopic dermatitis and allergic illnesses.[32]
- Echinochloa esculenta (barnyard millet) is a minor plant. millet variety grown in India, Japan, and China in the world and is used as a food and animal feed.[34]

It has the following nutrients per 100 g, which correspond to: [33].

- Calories: 300 kcal
- Fat: 3.6 g
- Dietary Fiber: 13.6 g
- Carbohydrate: 55 g
- Calcium: 22 mg
- Vitamin B1: 0.33 mg
- **Iron: 18.6 mg**
- Vitamin B3: 4.2 mg

Enhancers of iron absorption in barnyard millet -[34].Barnyard millet has a sufficient amount of nutrients, high iron content, and low glucose index (Amadou et al., 2013). The fermentation of L.'s barnyard millet plantarum has a beneficial effect on the nutritional content and antioxidant activity of millet and also extends the shelf life of millet-based products probiotic supplements

Inhibitors of iron absorption in barnyard millet -Natural protein glycation inhibitors derived from barnyard millet may be a more efficient way to manage protein glycoxidation and AGE formation and offer advantages without the negative side effects of synthetic drugs. On the other hand, the antiglycation properties of barnyard millet have not been thoroughly studied.[67]Amadori products are thickened, dehydrated, and oxidised in the last stages to provide premium glycation products (Vistoli et al., 2013) . This protein glycation is connected to glycoxidation, which results in the creation of oxygen and active carbonyl intermediates.

Additionally, several particular Glycation End (AGE) products such pentosidine, pyrraline, crossline, argpyrimidine, and pentolysine cause oxidative damage in cells and change their regular biological processes[32].

5 Major Diseases of Barnyard Millet (With Management) | Plant Diseases[35].

1.Head Smut

2. Grain Smut

3. Kernel Smut

4. Leaf Spot or Blight

Health Benefits of Barnyard Millet;[36]

1. Low in Calories

2.Rich in Fiber

3.Low Glycemic Index

4. Gluten-Free Food

5.Good Source of Iron

Pearl millet : Pearl millet, also known as bulrush millet (Pennisetum glaucum (L.) R. Br.), is a tropical cereal grass with small grains. It is also known as P. typhoides, P. Americanum, or P. spicatum. There are other slang terms, including "bajra" (in India), "Gero" (in Nigeria's Hausa language), "hegni" (in Niger's Djerma language), "sanyo" (in Mali), "dukhon" (in Sudan's Arabic), and "mahangu" (Namibia).With an annual production of over 14 million tones worldwide, pearl millet is the most significant millet in terms of quantity (Mt) [37]. In the last two decades, the world's production has only marginally increased, primarily as a result of disregard and preference for maize. However, due to the crop's specialized weh adaptation to heat and aridity, pearl millet yield may increase as the world becomes hotter and drier. Around 200 years ago, pearl millet farming is thought to have spread to East and Central Africa, India, and other dry regions [31].

Benefits of pearl millet [38].

1.Pearl millet promotes heart health

2.Pearl millet manages diabetes

3.Pearl millet prevents cancer:

4.Pearl millet prevents anemia

Enhancers of iron absorption in pearl millet - Breeding goals for pearl millet include resistance to harmful diseases such downy mildew, ergot, smut, rust, and head Mould of pearl millet as well as improved nutritional quality, saline adaptability, stover feeding value, high tillering, and drought tolerance [39].

Inhibitors of iron absorption in pearl millet -By using chromatographic techniques incorporating CM-sephadex and SP-Sepharose cation exchange columns and ammonium sulphate precipitation, a cysteine protease inhibitor with antifungal activity was extracted from pearl millet seeds and refined to homogeneity. Its molecular mass was determined by molecular characterization to be 24 Kd, and its isoelectric point was 9.8 [40]

Finger millet : It is also known as ragi in India, dagusha in Ethiopia and Eritrea, and wimbi in Swahili in East Africa. In English, finger millet is often referred to as bird's foot, coracana, and African millet. It is a staple diet for millions of people living in the semi-arid tropical regions of Africa and Asia. Finger millet is the fourth most popular millet in the world, following Panicum millaceum, Setaria italica, and pennisetums (pearl millet) (proso millet). It is projected to make up around 8% of the area and 11% of the global production of millets[31].

Growing finger millet takes a little bit more water than growing the other millets. With a yield of 1150 kg ha-1 in elevated areas, it is the most productive among the millets. The crop can be grown in regions with annual precipitation ranging from 500 to over 1000 mm in elevations up to 2000 m. Finger millet annual world production is at least 4.5 million tones, of which Africa produces about 2 million tones.[31]

Health benefits of Finger Millet[44].

1. Controls Diabetes

2. Reverts Skin Aging

4. Bone health

5. Anti-cancer potential.

Nutrients per Serving [45].

- Calories: 189
- **Protein**: 6 grams
- **Fat**: 2 grams
- **Carbohydrates**: 36 grams
- **Fiber**: 4 grams

Enhancers of iron absorption in finger millet:millets provide a variety of nutrients to the diet, they are a fantastic way to increase the iron density of the diet. The daily iron and calcium intakes will increase by 50% and 350%, respectively, if finger millet (ragi) is substituted for just 100 gm of the daily cereal (rice) intake.[48]

Inhibitors of iron absorption in finger millet: Ragi also includes other antinutrients, including phytates and polyphenols, which are known to prevent the absorption of iron. White finger millet typically contains 0.04–0.09% polyphenols, whereas brown cultivars have 0.08–3.47%. Ragi is most frequently consumed in its dark variant. The less popular variety is the white ragi[49]

Little millet : Panicum sumatrense, sometimes known as little millet, is an essential minor grains, which are widely grown in the tropics and are a staple food for groups with low incomes in some nations. In addition to providing minerals and vitamins, little millet is a comparable supply of protein, fat, carbs, and crude fibre to other cereals like rice and wheat. Additionally, it contains phytochemicals such tannins, phytate, phenolic acids, and flavonoids [50].

Nutrition-Based Health Benefits Of Little Millet-[51]

1.High in protein

2.Promote healthy digestion

3.Prevents anemia

4.Control diabetes

5.Support Weight loss:

A 100 grams serving of little millet contains:[51]

- **Calories:** 329
- **Protein:** 7.7 grams
- **Fiber:** 7.6 grams
- **Fat:** 4.7 grams
- **Carbs:** 67 grams

Inhibitors of iron absorption in little millet-Four stored grains and four phytophagous insect pests had their gut α amylases tested to see how three proteinaceous inhibitors isolated from tiny and Finger millet affected their ability to digest food.On the other hand, proteinaceous inhibitors from finger millet (FMCO11 and FMCO13) and little millet (LMCO3) inhibited insect-pests' amylases in varying degrees. The two compounds with the highest levels of inhibition against Callosobruchus chinensis -amylase were LMCO3 and FMCO13, with respective inhibition percent's of roughly 70% and 50%.[52].

Enhancers of iron absorption in little millet -As they provide a variety of nutrients to the diet, millets are a fantastic way to increase dietary iron density. When finger millet (ragi) is substituted for just 100 g of daily cereal (rice), daily iron and calcium intakes increase by 50% and 350%, respectively. Although these are great advantages, they may be countered by the ragi grain's high inherent phytate content, which may inhibit iron absorption [53].

Foxtail millet: The annual grass foxtail millet, scientifically known as Setaria italica (also known as Panicum italicum L.), is cultivated for human consumption. It is Asia's most frequently grown millet species and the second-most widely planted millet species overall [55].

Foxtail millet has the conventional architectural form of a domesticated plant, which consists of a single stalk or a few tillers with enormous inflorescences that mature essentially simultaneously. A fully developed foxtail millet plant has thin, upright, and leafy stems that range in height from 120 to 200 cm (3.9 to 6.6 feet) [56].

Benefits of Foxtail Millets: [56]

1.**Proper functioning of the nervous system**

2. **Protects Bone health and muscle health**

3. **Good for Cardiac Health**4. **Regulates blood sugar level**.

4. **Lowering Blood Cholesterol**

Table 5-Nutritional Value of Foxtail Millets[56]

Proteins	12.3 grams
Fat	4.3 grams
Carbohydrates	60.9 grams
Crude Fibre	8 grams
Minerals	3.3 grams
Calcium	31 mg
Phosphorous	290 mg
Iron	**2.8 mg**
Energy	331 kcal

Enhancers of iron absorption in foxtail millet -Nitrogen application in soils with low available nitrogen is beneficial for enhancing (Increasing) productivity. Nitrogen in combination with phosphorus, or the recommended dose of balanced fertilizer, can increase foxtail millet yield [59].

Inhibitors of iron absorption in foxtail millet-CO7 cultivar of foxtail millet (IC50, 22.37 and 57.26 g/ml) and CO4 cultivar of little millet (IC50, 18.97 and 55.69 g/ml) soluble and bound fractions inhibited -glucosidase strongly [60]

Proso millet : Proso millet (Panicum miliaceum L.) is an annual cereal crop that was domesticated around 10,000 years ago in China's semiarid regions. It is grown primarily in India, Nigeria, Niger, and China. Despite its high nutritional and health benefits, proso millet is used as fodder and bird seed in Europe and North America.[61]

Proso millet is also known as common millet, hog millet, broom corn, yellow hog millet, Hershey millet, and white millet. Proso millet is a warm-season grass that can produce seed within 60 to 100 days of planting. It has a low moisture requirement due to its relatively short growing season and is capable of producing food or feed where other grain crops would fail. Proso millet was introduced to the United States' eastern Atlantic Coast by European immigrants in 1875, but it is now mostly grown in the Great Plains.[62]

Health benefits of Proso Millet [63]

1.Beneficial in anti-ageing.

2.Beneficial for nervous system

3.Beneficial in preventing pellagra and other Niacin dependent conditions

4.Useful for strengthening bones

Mineral elements- source : Millet, proso | Tables of composition and nutritional values of feed

Table 6

Parameter		As fed	On DM	Unit	Other	Unit
Calcium		0.4	0.4	g/kg		-
Phosphorus		2.7	3	g/kg		-
Phytate phosphorus		1.8	1.9	g/kg	65	% P
Magnesium		1.2	1.3	g/kg		-
Potassium		3.7	4.1	g/kg		-
Sodium		0.08	0.09	g/kg		-
Chlorine		0.04	0.05	g/kg		-
Sulfur		1.1	1.2	g/kg		-
Dietary cation-anion difference		30	34	mEq/kg		-
Electrolyte balance		98	109	mEq/kg		-
Manganese		12	13	mg/kg		-
Zinc		29	32	mg/kg		-
Copper		6	7	mg/kg		-
Iron		53	58	mg/kg		-
Selenium		0.2	0.2	mg/kg		-
Iodine		0.05	0.05	mg/kg		-

*The iron content of millets was 2.60g, 7.0g, in little millet, proso millet.[64]

Inhibitors of iron absorption in proso millet : Like oleic acid from olive oil and polyunsaturated fatty acids (PUFAs) like-Ghama linoleic acid, proso and Japanese millet containing LA, which was an HDAC inhibitor, could be useful in preventing cancer. Other fatty acids like oleic and Ghama linoleic acids were also present in proso and Japanese millet, with the amount of LA in each being inversely correlated with the inhibitory activity against HDAC and cancer cell growth. Even though there is conflicting evidence regarding the anti-tumor activity of PUFAs, including LA, in vivo, our findings provide an intriguing explanation: the anti-tumor effect of PUFAs may depend on this HDAC inhibitory activity and/or CYP17 inhibitory activity.[65]

CONCLUSION :

Iron is an important mineral the body needs to make hemoglobin, a substance in the body that carries oxygen from the lungs to tissues throught out the body. These studies saying that some constituents are modifying the iron absorption in the millets. Millets are an excellent approach to boost dietary iron density since they offer a variety of nutrients to the diet. Just 100 g of daily cereal (rice) can be replaced with finger millet (ragi), increasing daily iron and calcium intakes by 50% and 350%, respectively. The soluble and binding fractions of the CO7 cultivar of foxtail millet (IC50, 22.37 and 57.26 g/ml) and CO4 cultivar of small millet (IC50, 18.97 and 55.69 g/ml) both strongly inhibited -glucosidase. It is advantageous to apply nitrogen to soils with low levels of accessible nitrogen to increase productivity. The recommended amount of balanced fertilizer or the addition of nitrogen and phosphorus can enhance foxtail millet yield. Traditional food processing and preparation techniques that improve the bioavailability of micronutrients in diets based on cereals are available at the household level for pearl millet. The techniques include germination, fermentation, hydrothermal processing, blanching, decortication, and soaking. These techniques reduces the levels of phytic acid and polyphenols, which improves iron bioavailability. Lactobacillus plantarum 299v is used to increase iron absorption in pearl millet. The bioavailability of iron was increased in proso millet by fermenting raw grains of rice and black gram dal. Because millets contain a lot of dietary phytates and fiber, their iron bioavailability is low. Processing methods like soaking, germination, and fermentation can increase iron absorption. Barnyard millet is treated with a combination of Lactobacillus rhamnoses GG, which enhances iron absorption. So iron absorption in millets can be improved by combining them with vitamin C.

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