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Exploring the Nutritional and Therapeutic Potential of Millets: A Fusion of Traditional Grains and Modern AI Technology

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A B S T R A C T

Feeling stuck in the Stone Age health-wise? It's time to upgrade with millets—ancient grains with a modern AI twist! These nutritional powerhouses aren't just surviving—they're thriving, thanks to cutting-edge technology uncovering their hidden health benefits.

Millets, once relegated to grandma's pantry, are now elevated by AI insights. With algorithms decoding their nutritional secrets, these grains are ready to combat diabetes, heart disease, and cancer. AI acts as your health sidekick, analyzing every bite to reveal its disease-fighting potential—it's "grain-brain" synergy at work. Loaded with antioxidants [1], millets protect your cells from oxidative stress, keeping you vibrant. They're also gluten-free [2], ideal for sensitive stomachs tired of wheat woes [3]. High in fiber, millets fuel your digestive system like a perfectly tuned AI algorithm—ensuring smooth, efficient functioning. These grains don't stop there! Packed with phytochemicals [4], millets fight diabetes, obesity, and more. Each bite brings you closer to wellness, backed by AI-powered insights into their hidden health potential. And yes, millets taste great! They're versatile enough for any meal—fluffy breakfast cakes, savory lunch balls, or creamy puddings. Just like AI chatbots, they easily adapt to your needs, making healthy eating both fun and delicious. In this new era of wellness, ancient grains and AI join forces to redefine healthy living. Together, they help you not just live longer but live better. So, ditch processed junk and embrace the "millet-elligence" revolution! Welcome to a future where millets nourish both body and soul—one smart bite at a time [5].

Keywords: Antioxidants, High Fiber, Phytochemicals, AI Insights, Disease-Fighting Potential, Grain-Brain Synergy, Gluten-Free, Diabetes Management, Ancient Grains, Body and Soul Nourishment

1. Introduction

In a world filled with dietary trends, the humble millet reemerges as a nutritional powerhouse of the future. Often overshadowed by wheat and rice, millets are making a comeback from the soils of developing nations to the tables of health enthusiasts worldwide. India leads in millet production, with these resilient grains demonstrating their capacity to thrive where other crops falter, offering hope in the fight against malnutrition and chronic diseases. A deeper dive into the millet family reveals a variety of species, each with distinct agricultural benefits. Pearl millet conquers arid lands, while Finger millet enriches traditional diets with its calcium-rich profile. This grain diversity ensures not only robust ecosystems but also highly nutritious diets. The culinary [6] versatility of millets spans from rustic porridges to elegant millet-based pasta, effortlessly transitioning between traditional kitchens and gourmet restaurants. Whether warming a winter morning or adding flair to a dinner table, these grains showcase their ability to fit into every meal. Nutritionally, millets deliver an impressive array of macronutrients and micronutrients [7]. With calcium levels rivaling dairy, superior protein content, and fiber profiles that surpass many modern superfoods, millets challenge the conventional nutritional hierarchy. Their low gluten levels and high methionine content offer a haven for those with gluten intolerance or diabetes [8].

Millets also wield powerful nutraceutical properties. Packed with antioxidants, phenols, and flavonoids, they combat chronic diseases like heart disease and cancer. These "free radical ninjas" act as a cellular defense system [9], promoting health and longevity. Studies suggest that some millet varieties may even target and neutralize harmful cells, offering precision-like benefits [11]. The diversity of millets includes Pearl, Finger, Proso, Foxtail, Kodo, Little, and Barnyard millets, each contributing unique flavors and benefits. High fiber content supports satiety and weight management [12], encouraging balanced eating habits and reducing the risk of overeating. As we embrace this grain revolution, millets remind us that small changes can have significant impacts. They are paving the way for sustainable nutrition, health, and wellness, offering a path toward a healthier future with every bite.

2. Millet-izing Your Diet

Joining the millet movement is easier than you might think, and the benefits are well worth it. Start by exploring the variety of millets available—each one brings its own unique flavour and texture. You can try pearl millet in a couscous-style dish, enjoy a warm bowl of finger millet porridge, or toss foxtail millet into a refreshing salad. Let your creativity shine as you incorporate millets into your meals. From fluffy millet pancakes to start your day, to Savory millet bowls for lunch, and creamy millet puddings for dessert, the possibilities are virtually endless. Millets have been staples in different cuisines across the globe, so take inspiration from traditional recipes and get adventurous with new flavour combinations. With each meal, you're not only nourishing yourself but also supporting a more diverse and sustainable way of eating.

Type of millets	Chemical composition	Benefits
Pearl millet	Tannins, phenols, flavonoids, steroids, iron, zinc, magnesium, copper, manganese, potassium, phosphorus, omega 3 fatty acids, folic acid, vitamin A, vitamin B, vitamin C.	Dilates blood vessels, promotes improved blood circulation, prevents arterial blockages, reduces LDL (low density lipoprotein) cholesterol, reduces your risk of developing type 2 diabetes, and reduces risk of asthma.
Foxtail millet	Calcium, potassium, iron, manganese, zinc, copper, phenols, flavonoids, tannins, carotenoids, ferulic acid, chlorogenic acid, and p-coumaric, tocopherol, and tocotrienol, vitamin A, vitamin E, folic acid, and vitamin B12.	Helps maintain a healthy cardiovascular system, improves glycemic control, good for skin and hair growth, maintains healthy bones and muscles, improves immunity during pregnancy, and reduces cholesterol.
Proso millet	Calcium, phosphorus, potassium, sodium, magnesium, manganese, iron, magnesium, zinc, niacin, B-complex vitamin, folic acid, flavonoids, phenolic acid derivatives and alkaloids.	Lowers blood pressure and reduces the risk of stroke, heart attack and atherosclerosis, stimulates nervous system, high in antioxidants, and reduces risk of diabetes.
Sorghum millet	Fibers, polyunsaturated fatty acids, phytosterols, phenolic acid, policosanols, tannin, anthocyanin, iron, zinc, magnesium, potassium, phosphorus, vitamin B.	High in antioxidants, reduces inflammation, reduces risk of cancer, aids in weight loss, helps alleviate oxidative stress in kidney disease patients, and lowers glucose levels.
Barnyard millet	Fiber, iron zinc, calcium, magnesium, phosphorus, phenols, flavonoids, tannins, terpenoids, potassium, selenium, folate, pantothenic acid, niacin, riboflavin and vitamin B, vitamin C, vitamin E, and vitamin K.	Fights against diabetes, cardiovascular diseases, obesity, skin problems, cancer and celiac disease.
Finger millet	Phytates, polyphenols, tannins, trypsin inhibitory factors, fiber, iron, manganese, calcium, magnesium, zinc, phosphorus, vitamin B, folate, niacin, thiamin, and riboflavin.	Strengthens bones, controls blood sugar, good for skin, improves digestive and heart health, builds healthy cells, aids in nervous system function.
Browntop millet	Calcium, iron, zinc, copper, manganese, niacin, thiamin, vitamin B, riboflavin, fiber, flavonoids, quinones, tannins, and resin.	Supports energy generation, promotes digestive health, cognitive health, immune system function, promotes digestive health and hematopoiesis(red blood cell creation)
Little millet	Iron, phosphorus, niacin, riboflavin, thiamin, calcium, magnesium, fiber, copper, phenolics, flavonoids, alkaloids, saponins, and vitamin B.	Boosts immunity, rich in antioxidants, helps maintain healthy bones, aids in tissue repair, and supports muscle and nerve function.
Amaranth millet	Calcium, folate, iron, magnesium, phosphorus, potassium, zinc, sodium, copper, manganese, selenium, thiamin, riboflavin, niacin, vitamin B6, vitamin E,	Anti-inflammatory and antioxidant effects, is rich in fiber, fights heart disease and digestive issues, lowers cholesterol levels, and aids in weight loss.

	tocopherol, and tocotrienol.	
Kodo millet	Contains derivatives of hydroxybenzoic acid and hydroxycinnamic acids, myricetin, catechin, luteolin, apigenin, daidzein, naringenin, kaempferol, quercetin, vitamin B3, vitamin B6, and folic acid, calcium, potassium, magnesium and zinc.	Aids in anemia(high iron levels), diabetic friendly, blood purifier, aids in kidney function, strengthens immune system and cardiovascular mussels, reduces risk of cancer, higher collagen levels in body, and improves bowel movement

3. Millets: Chemistry and Stability

In the grand culinary theater of the world, where grains play the starring roles, millets have emerged from the wings, ready to take center stage as the Nutri-cereals of the future. With a script enriched by phytochemicals, nutrients, and antioxidants[13], these tiny titans are not just playing their parts; they're rewriting the playbook for healthy eating. Imagine millets as the unsung heroes, packed with a nutritional ensemble that includes carbohydrates doing the heavy lifting, proteins delivering punchy lines, fatty acids adding flavor, and a chorus of vitamins and minerals providing the background score. Among this cast, Finger millet and Kodo millet shine as the stars, loaded with phenolics, tannins, and phytates—nature's own antioxidant ensemble, ready to combat oxidative stress with their natural flair. Diving into the science, with high-performance liquid chromatography [14]and tandem mass spectrometry as the directors, we've identified over 50 phenolic compounds in these grains. It's like uncovering the secret ingredients of a blockbuster potion, with benzoic and cinnamic [15]derivatives playing the lead roles. Add to this a supporting cast of flavonoids, and you've got a nutritional drama rich in quercetin and flavan-3-ols, ready to steal the show. But what's a plot without a twist? Enter artificial intelligence, the wizard behind the curtain, ready to optimize the bioavailability of these nutrients, ensuring that every bite of millet is tailored to meet the dietary needs of its audience. Imagine AI as the culinary critic[16], analyzing the nutritional content and recommending the perfect millet dish to complement your health script. In the mineral department, millets don't skimp on the essentials. With a lineup featuring B complex vitamins taking center stage, and calcium, phosphorus, iron, and zinc in supporting roles, these grains are set to dazzle with their nutritional versatility. Yet, the plot thickens as we learn that millets are not just about what's on the surface. They're rich in proteins, essential amino acids, and come in two types of fatty acids, adding layers to their character. However, no hero is without their challenges. The process of boiling might dim their antioxidant glow, and mechanical processing could see them shedding some of their fibrous costume. Yet, like any good protagonist, millets have a way of turning adversity into advantage. Germination [17]and fermentation[18], the plot twists in our story, enhance their nutritional profile, making them more digestible and enriching their content of proteins, enzymes, and flavonoids. Yet, as in any epic tale, there's a call for balance. While fermentation can amplify certain nutritional aspects, it might also lower the curtain on mineral content. But fear not, for the polyphenols in millet [19] are versatile actors, stable across a range of pH settings, ready to deliver their health-promoting performance under various conditions. Fig 1 illustrates the multifaceted benefits of millet as a crop, emphasizing its roles in economic, nutritional, and food security. The diagram highlights millet's advantages, such as its low investment requirement, high nutritional content, climate resilience, and disease prevention properties, making it a sustainable agricultural option that supports both human health and environmental stability.

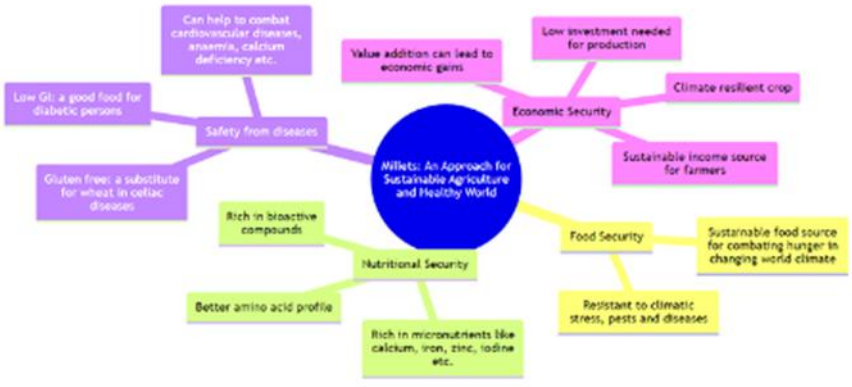

Fig. 1: Millets as a Holistic Solution for Sustainable Agriculture, Economic Growth, and Global Health Security

In the end, millets are not just grains; they're the superheroes of the dietary world, with AI as their sidekick, ensuring that every preparation method enhances their innate powers. As we close the curtain on this culinary spectacle, let's not forget that millets, with their rich repertoire of dietary Fibers, minerals, vitamins, and phytochemicals, are ready to take on the world, one healthy meal at a time. So, grab your forks, and let's give a standing ovation to millets, the grainy heroes ready to make our diets healthier, one pun at a time.

4. Millets: Tiny Titans Packed with AI-Powered Health Punch!

Move over, boring grains! Millets are here to "millet-ize" your diet with a powerful punch of nutrients and AI-backed benefits. Think of them as the "nutri-cereals" of the future, packed with more goodies than a superhero convention. But the fun doesn't stop there! Millets are "mineral maestros", boasting B vitamins, calcium, phosphorus, iron, and more. Each grain is a "nutrient orchestra", playing a different tune depending on where it grew (imagine them practicing under the African sun or Indian sky!). Feeling protein-deficient? Not with millets! They're "essential amino acid aces [20] Seed protein of millets: amino acid composition, proteinase inhibitors and in-vitro protein digestibility except for lysine and threonine (don't worry, AI is working on finding those missing notes!). And let's not forget the "fatty acid fiesta" happening inside these grains, with both free and bound forms for complete nutritional fun.

But hold on, there's more! Millets are "dietary fiber [21] divas", keeping you feeling fuller for longer and your gut microbiome singing happy tunes. Soluble and insoluble fibers join forces such as "fiber-tastic superheroes", leaving you feeling "regulicious" and ready to conquer the day. Now, the AI twist: cooking methods matter! Boiling might "reduce their antioxidant rockstar status", so AI scientists are developing "millet-ific cooking algorithms [22] for maximum health benefits. Processing? Not ideal, as it can make the millets lose some of their "nutritional superpowers". But fear not! Germination and fermentation might just be the "bioavailability boosters" we need to unlock even more goodness. Imagine AI chefs whipping up "fermented millet [23] feasts", enhancing flavors and digestibility while reducing those pesky anti-nutrients. Now that's a future we can all get behind! So, are you ready to join the "millet revolution"? Ditch the processed junk and embrace these AI-powered nutritional powerhouses. With their diverse flavors, impressive health benefits, and exciting possibilities, millets are more than just food – they're a gateway to a healthier, happier future.

5. Pharmacokinetic Perspectives of Millets

The pharmacokinetic journey of millets through the human body is a fascinating exploration of their impact on health and well-being. Millets, rich in bioactive compounds such as phenolic acids, flavonoids, and tannins, play a significant role in the prevention and treatment of various chronic diseases. These bioactive compounds, including gallic acid, protocatechuic acid, quercetin, and proanthocyanidins, have been shown to have antioxidant, anti-diabetic, anti-tumorigenic, anti-atherogenic, and antibacterial properties [24][25]

. The slow-release energy from millets, attributed to their high dietary fiber content, aids in the management of blood sugar levels, and offers potential benefits for individuals with diabetes [24]. Furthermore, the prebiotic fibers in millets support a healthy gut microbiota, influencing overall health, from metabolism to immune function [24]. Ongoing research is focused on understanding the pharmacological activities of these bioactive compounds from millets against lifestyle diseases such as diabetes mellitus, atherosclerosis, and hypertension through pharmacokinetics and molecular modelling methods [24]. The potential for personalized nutrition tailored to individual metabolic responses also presents an exciting frontier in dietary health. The diverse range of bioactive compounds in millets, their impact on the human body, and their potential for preventing and managing chronic diseases highlight the significant role of millets not only as a source of nutrition but also as a partner in promoting good health. As depicted in Fig 2, millet stands out nutritionally compared to other staple grains like rice, wheat, oats, and rye. It offers a higher protein content (11g per 100g) than rice and rye and is a particularly rich source of dietary fiber (8.5g per 100g) compared to brown rice and rye. Millet is also notable for its high calcium content (344 mg/100g), significantly surpassing the calcium levels in rice and wheat. Additionally, millet provides a substantial amount of phosphorus, making it a nutrient-dense option that supports both bone health and dietary needs for populations with limited access to other sources of these essential nutrients.

Nutrient	Millet (avg)	Rice (brown)	Wheat	Oats	Rye
Energy (kcal/100g)	378	370	340	389	338
Protein (g/100g)	11	7.9	13.7	16.9	8.8
Carbs (g/100g)	73	77.2	71.2	66.3	71.7
Starch (g/100g)	~65	~70	~60	~55	~60
Fat (g/100g)	4.2	2.9	2.5	6.9	1.6
Dietary Fiber (g/100g)	8.5	3.5	12.2	10.6	14.6
Calcium (mg/100g)	344	23	29	54	33
Phosphorus (mg/100g)	287	333	346	523	376

Fig. 2: Comparative Nutritional Profile of Millet and Other Staple Grains

Embarking on a journey through the pharmacokinetic landscape of millets offers a fascinating glimpse into how these ancient grains can influence our health from the inside out. Pharmacokinetics, the study of how substances move through the body, becomes a crucial lens through which we can appreciate millets not just as food, but as agents of health and well-being.

6. The Journey of Millets in Our Body

6.1 Absorption

When we consume millets, the journey begins with absorption [26]. Millets are rich in phenolic compounds, antioxidants that must navigate the complex environment of our digestive system. The fiber in millets plays a dual role here, slowing down digestion to allow a more gradual absorption of sugars, thus providing a steady release of energy and aiding in the management of blood sugar levels.

6.2 Distribution

Once absorbed, the nutrients and bioactive compounds in millets distribute throughout the body. The phenolic compounds, now entering the bloodstream, travel to various tissues, offering their antioxidant protection far and wide. This distribution is not just about delivering nutrients but ensuring that every cell gets its share of millets' protective benefits [27].

6.3 Metabolism

The metabolism of millets involves a fascinating interplay between our own enzymes and our gut microbiota. The bound phenolic compounds in millets are transformed into more accessible forms, allowing our body to utilize their antioxidant properties fully. This process underscores the importance of the food matrix and processing methods, which can significantly affect the bioavailability and impact of these compounds.

6.4 Excretion

Finally, what goes in must come out. The fiber in millets also plays a critical role in excretion, aiding in gut health and ensuring that waste products are efficiently removed from the body. This not only helps keep our digestive system clean but also reduces the risk of colorectal diseases. Fig 3 illustrates the various processing methods applied to millet grain and the diverse range of end products derived from each process. The diagram showcases pathways such as milling, germination, roasting, and grinding, leading to the production of items like composite flours, bakery products, breakfast cereals, fermented foods, beverages, and supplementary foods. This highlights millet's versatility in food production and its potential for creating a wide array of both traditional and modern food products.

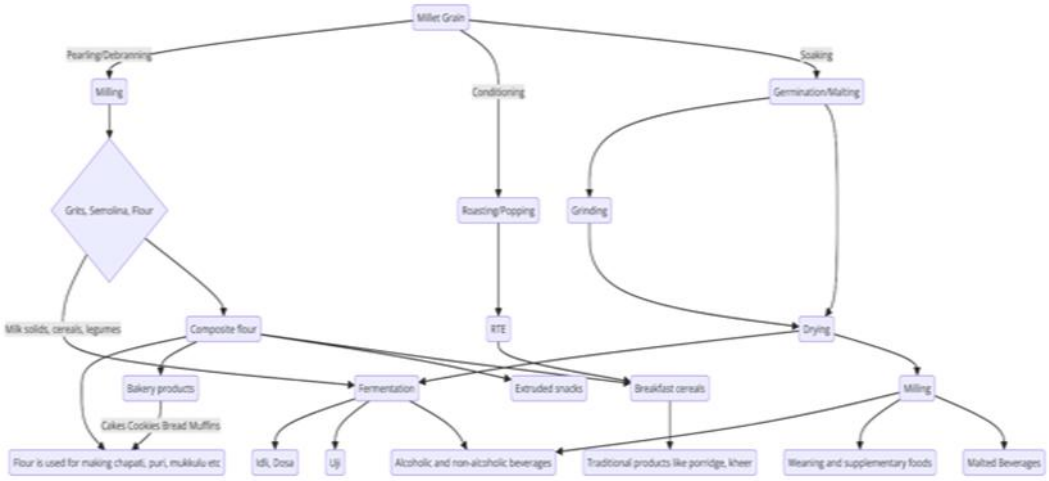

Fig. 3: Processing Pathways and End Products of Millet Grain

7. Health Benefits

Embark on a whimsical journey where millets aren't just grains but mighty warriors in the epic saga of health, and AI, our digital Dumbledore, conjures spells to amplify their powers. Let's dive into this fantastical world where nutrition meets technology in a quest to vanquish health foes.Millets? Don't underestimate these ancient grains! They're like nutritional [28] ninjas, quietly packing a powerful punch against chronic diseases. AI scientists are joining the fight, analysing every "millet-ific" detail to unlock their full potential. Buckle up for a fun, pun-filled ride through the health benefits of these tiny titans!

7.1 Obesity on the Run? Millets Join the Chase!

Excess weight got you down? Millets can help! Their unique properties, studied by AI detectives, might be the key to "millet-izing" your metabolism and promoting healthy weight management. Eating millets promote slow steady sugar levels in the blood. Eating foods with a low glycemic index (GI)

regulates fat percentage in the body [9]. This helps to reduce adipose tissue in the body and promotes weight loss [29]. Satiety Analysis: AI can aid in identifying phytochemicals (beneficial plant compounds) within millets that enhance satiety (feelings of fullness).

Metabolic Simulation: AI models can simulate metabolic pathways to pinpoint how millet components influence calorie burning and fat storage. This could optimize personalized millet-based weight management strategies. **Fig 4 depicts** the beneficial impact of millets on obesity management and associated health conditions. It shows how millets, due to their high fiber content, low glycemic index, and rich nutrient profile, can reduce hunger, stabilize blood sugar levels, and support metabolism. These effects collectively help lower calorie intake and insulin spikes, reducing the risk of obesity. Consequently, managing obesity with millets can lower the risk of related health issues, such as diabetes and cardiovascular diseases.

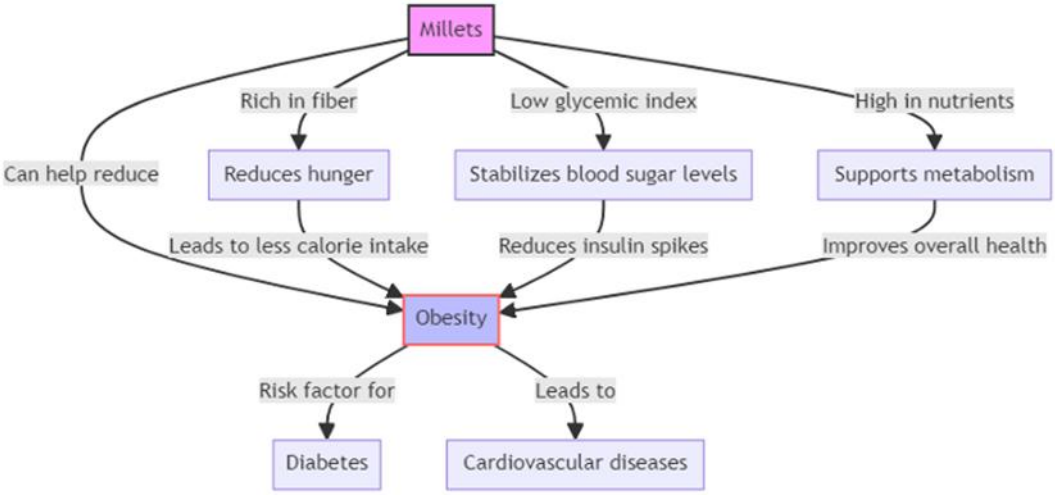

Fig.4: Role of Millets in Managing Obesity and Reducing Health Risks

7.2 Oxidative Stress? Not on Our Watch!

Oxidative stress [31] occurs when there's an imbalance between free radicals (unstable molecules that can damage cells) and antioxidants in your body. This imbalance can lead to cell and tissue damage, contributing to aging and chronic diseases such as cancer, diabetes, and heart disease. Now, imagine your body as a bustling metropolis under siege by these free radical forces. Enter millets, the unsung heroes equipped with an arsenal of antioxidants[32] including phenolic compounds and flavonoids, akin to an "Antioxidant Avengers" team. These tiny but mighty grains come charging into battle, neutralizing free radicals and restoring balance to your cellular city. Artificial Intelligence (AI) is playing a pivotal role in understanding and optimizing the antioxidant potential of millets. By analyzing vast datasets, AI can identify which types of millets pack the most potent antioxidant punch. It's like having a supercomputer strategize the deployment of our phenolic fighters and flavonoid friends to the frontlines where they're needed most. This precision allows for targeted nutritional recommendations, potentially leading to personalized diet plans that leverage the specific antioxidant profiles of different millet varieties to combat oxidative stress. Fig 5 illustrates the role of millets in mitigating oxidative stress due to their antioxidant content. The antioxidants in millets may help reduce oxidative stress, a factor associated with various diseases. By lowering oxidative stress, millet consumption can potentially reduce the risk of diseases linked to oxidative damage, including cardiovascular issues, diabetes, and cancer.

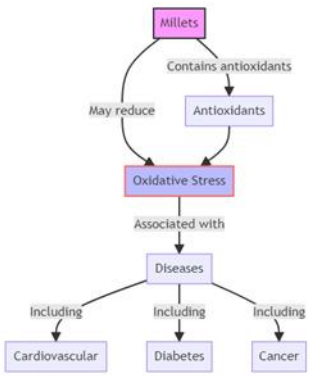

Fig.5: Antioxidant Benefits of Millets in Reducing Oxidative Stress and Disease Risk

7.3 Cancer Cells Beware! Millets are Coming!

The anti-cancer potential of millets is a burgeoning field of research. These grains are not just food but potential warriors in the fight against cancer. Early studies suggest that certain compounds in millets might act as "anti-cancer armor [33]disrupting the growth and spread of cancer cells. Imagine

these compounds as elite mercenaries navigating the complex terrain of the human body to target and neutralize malignant marauders without harming healthy cells.

AI steps in as the mastermind battle strategist, employing its computational prowess to sift through scientific literature and experimental data. It identifies patterns and connections that might elude human researchers, pinpointing which molecules in millets hold the most promise as anti-cancer agents. Furthermore, AI can simulate how these compounds interact with cancer cells [34] predicting their effectiveness and potential side effects without the need for extensive laboratory tests. This not only accelerates the pace of discovery but also significantly reduces the cost and time involved in developing new cancer therapies. **Fig 6 depicts** the potential anti-cancer effects of millets, showing how their antioxidant and fiber content may help neutralize free radicals, inhibit cancer cell growth, and reduce cancer risk.

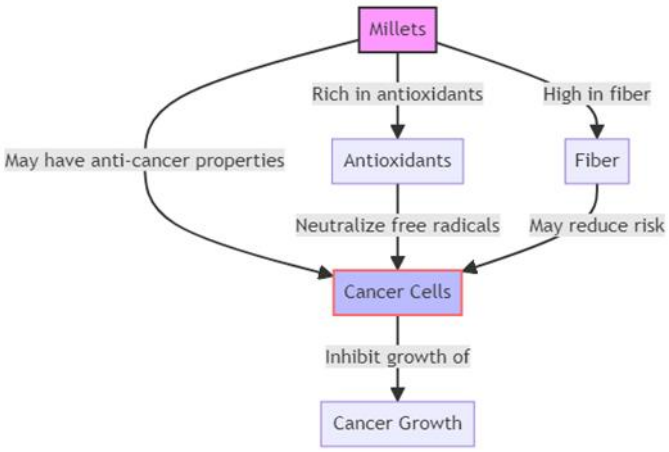

Fig.6: Potential Anti-Cancer Properties of Millets through Antioxidants and Fiber

In terms of references, while I cannot directly link to specific papers without current internet access, there's a wealth of scientific literature available in databases such as PubMed, ScienceDirect, and Google Scholar. Keywords such as "millets and antioxidants," "phenolic compounds in millets," "flavonoids and health," "millets and cancer," or "AI in nutraceutical research [35] can guide you to studies and review articles that delve into these topics. For instance, research papers might discuss the antioxidant capacity of different millet species or laboratory studies where millet extracts are tested against cancer cell lines, with AI methodologies applied to bioinformatics or cheminformatics studies to predict the bioactivity of millet-derived compounds.The symbiosis between AI and nutritional science represents a frontier in our fight against diseases. By harnessing the power of both, we're not only unlocking the secrets of traditional grains such as millets but also paving the way for innovative approaches to disease prevention and treatment. It's a humanized approach to science, where technology serves to amplify the benefits of nature's bounty, and every discovery brings us closer to a future where food truly is our medicine.

7.4 Diabetes Worries? Millets Have Your Back!

Struggling with blood sugar control? Millets might be the answer! Their ability to inhibit enzymes that break down sugars is being studied by AI, aiming to develop natural "diabetic defense strategies". Remember, millets are more than just food; they're AI-powered warriors for your health! Embrace their diverse flavors, explore exciting recipes, and join the millet revolution. With their impressive health benefits and the power of AI, these tiny titans are poised to transform our future, one delicious bite at a time! Millets' slowly digestible starch acts like a "blood sugar superhero [36] keeping you feeling steady and energized. AI researchers are analyzing different varieties and processing methods to find the ultimate "diabetic defense shield". Diabetes has emerged as a global health crisis, affecting millions of lives with its complex web of complications. In this scenario, millets, an ancient grain largely underestimated, emerge as a beacon of hope. These grains are not just food; they are a testament to the adage "Let food be thy medicine." Rich in fiber, low on the glycemic index, and brimming with nutrients that help manage blood sugar levels, millets can be a valuable ally in the fight against diabetes. But how do we optimize this ally's potential? Enter Artificial Intelligence (AI), the game-changer in diabetes management and millet research. Imagine AI as a meticulous scientist and a compassionate caregiver rolled into one. It sifts through vast amounts of nutritional data, identifying patterns and connections that can inform personalized diet plans for diabetes management. AI's ability to analyze and interpret complex datasets allows for a nuanced understanding of how different types of millets can benefit individuals with varying health profiles. It's such as having a personalized nutritionist at your disposal, one who understands the unique biochemical symphony of your body and how millets can play a harmonious part in it. As diabetes casts its shadow over the land, the millets, rich in magnesium and phenolic compounds, rise as the diabetes defenders. Their mission: to maintain the peace in blood sugar levels. AI, with its crystal ball of predictive analytics [37] identifies the most potent millet allies for everyone, crafting personalized dietary spells to keep the blood sugar beast at bay. AI technologies, including machine learning and data analytics, are being used to analyse vast amounts of nutritional data. These technologies can identify patterns and correlations [38] between millet consumption and various health outcomes, enabling the development of personalized diet plans that cater to individual health needs and preferences. It demonstrates the potential of using data analytics for personalized nutrition, though it focuses broadly on glycaemic response rather than millets specifically.

7.5 Millets in Blood Sugar Management

Millets have a low glycemic index (GI) compared to more common grains, making them beneficial for blood sugar control. AI can predict the impact of different millet varieties on an individual's blood sugar levels [39], allowing for the optimization of meal timing and portion sizes.

Starch Structure: AI can analyze the intricate starch structures of various millet types, predicting their impact on blood glucose release [40], glycemic index etc. Predictive Models: Machine learning algorithms can build personalized models that consider factors such as individual blood sugar responses and meal composition to suggest the ideal millet variety and timing for each person.

7.6 Millets' Anti-inflammatory Properties

Millets contain compounds that have been shown to possess anti-inflammatory [41] properties. Through AI, it's possible to analyze the specific components of different millet varieties and predict their efficacy in reducing inflammation for personalized dietary recommendations.

Millets are known for their anti-inflammatory properties due to the presence of polyphenols and other antioxidants, which help neutralize harmful molecules and lower inflammation levels [42]. The high fiber content in millets can also contribute to their anti-inflammatory effects by promoting the production of beneficial anti-inflammatory compounds [42]. Additionally, the presence of ferulic acid in millets plays a significant role in reducing inflammation [43] Antioxidant Targeting: AI can screen extensive databases to match specific millet antioxidants with various inflammatory pathways in the body, developing custom anti-inflammatory dietary strategies. Example: Bioactive compounds in finger millet and their health promoting activities: Inflammation Response Models: Machine learning can design inflammation response models incorporating millet's anti-inflammatory potential to suggest the best combination for a unique individual.

7.7 Millets for Heart Health

The high fiber, magnesium, and potassium content in millets contribute to cardiovascular health by managing blood pressure and cholesterol levels [44]. AI can match individuals with the millet variety that best supports their heart health, considering their unique health profiles and needs. Eating millets has been found to reduce the risk of developing cardiovascular disease. A study analyzing data from 19 studies with nearly 900 people found that consuming millets reduced total cholesterol by 8% and lowered BMI. The study also showed a decrease in low and very low-density lipoprotein cholesterol, as well as a reduction in blood pressure and BMI. These findings suggest that millets can contribute to better cardiovascular health and weight management [45]. Additionally, foxtail millet has been highlighted for its benefits for cardiac health, as it helps decrease cholesterol and triglyceride levels in the body, and has a lower glycemic index compared to other varieties, which is beneficial for heart health [46]. Furthermore, millets are full of soluble fiber, which can lower cholesterol levels and reduce the chances of heart disease. They are also good sources of magnesium, which may prevent heart failure. Therefore, incorporating millets into the diet may help in managing hyperlipidemia, reducing hypertension, and promoting overall heart health. Phytochemical Screening: AI algorithms can swiftly screen and pinpoint heart-healthy compounds in millet varieties. Risk Prediction: AI can help create predictive models analysing genetic markers, lifestyle factors, and millet consumption to provide more tailored dietary recommendations for reducing cardiovascular risk [47].

8. Challenges

The journey of millets from traditional, underutilized grains to being recognized as superfoods is fraught with challenges. Despite their rich nutritional profile and environmental benefits, millets face hurdles in awareness, availability, accessibility, and preparation complexity. Let's delve into these challenges in a humanized manner, reflecting on the collective effort needed to overcome them and bring millets to the forefront of global diets.

8.1 Limited Awareness

One of the primary obstacle millets faces is limited awareness. For decades, the global narrative around food has been dominated by a few major cereals such as rice and wheat, overshadowing the diverse benefits of millets [48]. This lack of awareness extends from consumers to policymakers, resulting in underinvestment in millet research and development compared to major crops [49]. The challenge is not just to introduce millets to people but to educate them about their nutritional and environmental advantages. Overcoming this requires innovative approaches, such as leveraging social media, educational campaigns, and community programs to highlight millets' role in sustainable agriculture and healthy diets.

8.2 Availability and Accessibility

Despite their adaptability to harsh growing conditions, millets' availability and accessibility are hindered by several factors. Inadequate infrastructure, such as limited access to irrigation, storage facilities, and markets, poses significant challenges for millet farmers [49]. Additionally, the economic cultivation of millets remains a challenge in regions such as Africa and India, where agricultural productivity needs enhancement to make millets a more economically attractive alternative [48]. Improving millet’s availability and accessibility requires concerted efforts from governments, NGOs, and the private sector to invest in millet-specific agricultural infrastructure and to implement policies that support millet farmers.

8.3 Complicated Millet Preparations

Another barrier to the widespread adoption of millets is the perceived complexity of their preparation. Traditional millet dishes often require time-consuming processing and cooking methods, which can deter modern consumers looking for convenience. This challenge is compounded by a lack of knowledge about how to incorporate millets into contemporary cuisines. Addressing this issue involves developing and promoting simplified, quick, and versatile millet recipes that fit into the fast-paced lifestyle of today's consumers. Culinary workshops, cooking shows, and online recipe platforms can play a significant role in demystifying millet preparations and showcasing their versatility [50].

8.4 Moving Forward

The path to mainstreaming millets involves navigating these challenges with innovative solutions and collaborative efforts. Raising awareness through education and marketing, improving millet-specific agricultural infrastructure, and simplifying millet preparations can collectively enhance millet's appeal. As the world moves towards more sustainable and nutritious dietary choices, millets stand out as a promising option. Their journey from the shadows to the spotlight of superfood stardom is not just about changing diets but about transforming agricultural practices, enhancing biodiversity, and promoting food security in the face of climate change. The challenges millets face is significant, but so are the opportunities they present for a sustainable and healthy future. It's a collective journey that requires the involvement of farmers, researchers, policymakers, chefs, and consumers. Together, we can turn the tide for millets, ensuring they take their rightful place on our plates and in our fields.

A. **Overcoming Limited Awareness: Leveraging AI for Millet Education and Promotion**

AI is set to revolutionize the way we perceive and consume millets. By harnessing the power of social media, AI can create engaging content that resonates with a wide audience, making millets more than just a food item but a movement. AI-driven chatbots can provide instant support and assistance to customers, enhancing the shopping experience and fostering a community around millet consumption [51]. The United Nations' declaration of 2023 as the International Year of Millets is expected to further raise awareness and improve the livelihoods of farmers and suppliers in regions threatened by drought and climate change [51]. Figure 7 illustrates how AI technologies can be used to increase millet awareness and promote consumption through educational content, social media campaigns, and interactive learning platforms. Data analysis helps identify key demographics for targeted outreach, enabling customized promotion strategies. These combined efforts aim to educate, engage, and foster hands-on learning, ultimately boosting millet awareness and encouraging greater millet consumption.

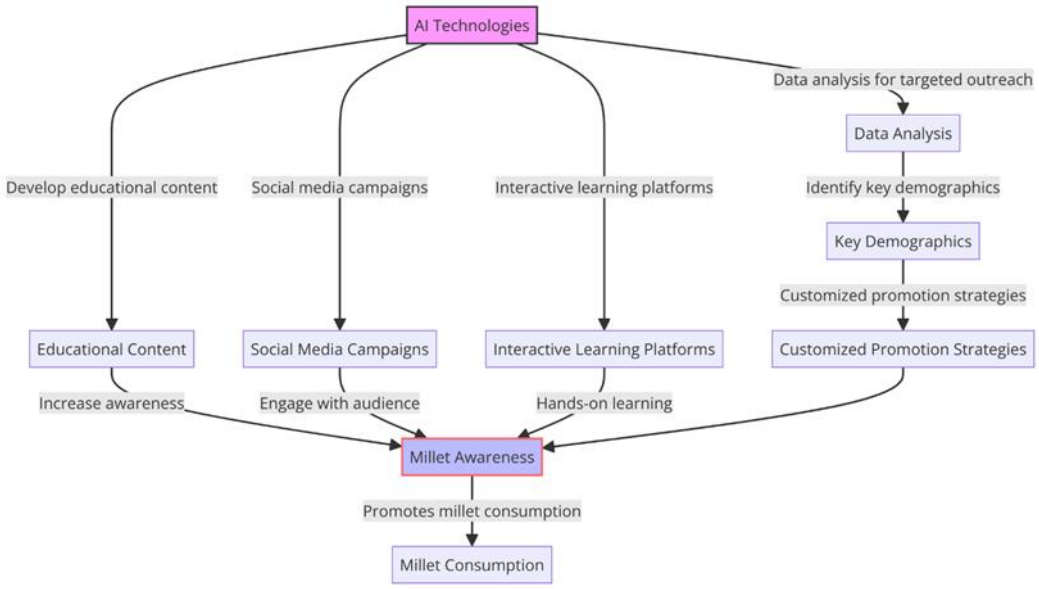

Fig.7: Leveraging AI Technologies to Enhance Millet Awareness and Consumption

B. **Tackling Availability and Accessibility: AI-Powered Supply Chain Solutions**

AI can optimize the entire supply chain of millets, from predicting market demands to streamlining distribution networks. By creating a decentralized "millet marketplace,"[52] AI can connect farmers directly with consumers, ensuring fair prices and real-time availability information. This approach can also support micro-financing initiatives and community-supported agriculture programs, making millets more affordable and accessible globally.

C. **Simplifying Millet Preparations: AI-Enabled Recipe Development and Cooking Assistance**

AI is transforming millet preparations from bland and complicated to flavourful and simple. Interactive recipe platforms and AI-powered cooking assistants can guide users through the cooking process, making it easier to incorporate millets into daily meals. Smart appliances and millet-specific kitchen gadgets can further simplify the cooking process, encouraging even novice cooks to try millet-based dishes [53]. The integration of AI in

promoting millets addresses the challenges of awareness, availability, and culinary complexity. By leveraging technology, millets can transition from being the "poor man's grain" to a celebrated ingredient on Michelin-starred menus and beyond [54]. Support for millet farmers is crucial, as they face challenges in research and development, policy support, and infrastructure [55]. By embracing AI and supporting millet farmers, we can ensure that millets become a staple in diets worldwide, contributing to a sustainable and nutritious future.

9. Conclusion

As we close the chapter on this gastronomic adventure, where science meets the humble grain [59] let's reflect on a future where our plates become the palette for a healthier tomorrow. The recent fusion of research in science and the culinary arts paints a vivid picture of diet's heroic role against the battalion of human ailments. It's in this vibrant landscape that millets, the unsung heroes of the grain world, emerge with a cape of polyphenols, a shield of flavanols, and a sword of essential nutrients, ready to battle the dark forces of non-communicable diseases. Imagine if you will, millets as the knights in shining armor, bestowed with the magical powers of antioxidants. These aren't your average grains; they're the Avengers of the agricultural realm, equipped with polyphenols, flavonoids, and carotenoids in their arsenal, launching a formidable defense against the nemeses of our health: diabetes, cancer, cardiovascular diseases, and the ever-persistent oxidative stress. In this narrative, AI isn't just a bystander; it's the wise wizard, conjuring insights from the depths of data dungeons, ensuring these grainy champions are recognized not just as food, but as nutraceutical knights. With their powers combined, they offer a beacon of hope for those in the realms of the semi-arid tropics, Africa, and the Indian subcontinent, lands rich in millets yet plagued by the rise of non-communicable diseases. Yet, as our story unfolds, we find that not all heroes have been sung, with great millet and finger millets hogging the limelight, leaving their kin in the shadows. It's here that AI, with its infinite wisdom and analytical prowess, steps in, urging us to turn our gaze towards the underexplored and underappreciated varieties, to uncover their hidden strengths and bring balance to the dietary force. Artificial intelligence (AI) holds the promise of transforming the millet production sector through enhancements in monitoring crop and soil health, as well as refining decision-making processes [60]

As we embark on this quest for knowledge, let us not forget the need for meticulous research, to ensure that the tales of these tiny titans aren't just lore but are backed by the science of their benefits. It's a call to arms for researchers to delve deeper into the fate of millets' phytochemicals during processing, to unveil how they wield their health-promoting powers in the theater of life. So, as we stand on the precipice of dietary revolution, let's rally behind these eco-friendly champions, armed with AI as our guide. For in the battle against the looming shadows of global warming and climate change, millets don't just offer sustenance; they promise salvation for our health and our planet [61] .And so, dear readers, let's raise our forks, not just in the act of eating, but in salute to millets and AI, the dynamic duo championing the cause of health, one grain at a time. In the epic saga of nutrition, they're not just characters; they're heroes, ready to transform our future, one delicious bite at a time.

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