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ABSTRACT

Finger millet (Eleusine coracana), commonly known as Ragi or nachni, is a nutritious cereal crop widely cultivated in Africa and Asia. In recent years, there has been growing interest in its potential health benefits, particularly due to its rich amino acid composition. This brief review explores the organochemistry of amino acids in finger millets, focusing on their structural characteristics, nutritional significance, and physiological roles. Amino acids are the building blocks of proteins and play crucial roles in various metabolic processes in humans and animals. Finger millets have been found to contain essential amino acids such as lysine, methionine, and tryptophan, which are often deficient in other cereal grains. Additionally, finger millets exhibit a balanced amino acid profile, making them valuable dietary components for meeting protein requirements. The review also discusses the impact of processing techniques on the amino acid content and bioavailability in finger millets, highlighting the importance of optimizing food processing methods to preserve their nutritional integrity. Furthermore, the bioactive peptides derived from finger millet proteins are examined for their potential health-promoting effects, including antioxidant, antimicrobial, and antihypertensive properties. Overall, this review provides insights into the organochemistry of amino acids in finger millets, emphasizing their nutritional significance and health benefits, and underscores the importance of incorporating finger millet-based products in the diet for promoting human health and well-being

Keywords: *Ragi, Organochemistry, Millets, Amino acid, Finger millet, etc.*

INTRODUCTION

Finger millets, scientifically known as Eleusine coracana or commonly known as ragi or African millet, is an ancient cereal grain, cherished for their resilience and adaptability to diverse agro-climatic conditions. Indigenous to Africa and Asia, these grains have been a staple in the diets of many communities for centuries and emerged as nutritional powerhouses, carrying immense importance in both traditional and modern diets. When it comes to nutrition, finger millet has a greater micronutrient density and is significantly richer in minerals than rice and wheat, the two most common cereal grains in the world [1,2]. Rich in essential nutrients such as dietary fibre, vitamins, and minerals, finger millets contribute significantly to human health and they are a potent source of complex carbohydrates with a low glycaemic index, making them an ideal choice for managing blood sugar levels. Additionally, finger millets stand out for their high levels of micronutrients, including iron and calcium. Unlike other cereals, finger millet boasts a gluten-free nature, making it a beneficial choice for people who are sensitive to gluten or have celiac disease. In underdeveloped nations, millet grains have enormous potential for processing into high-value foods and beverages. Moreover, millets are recommended for individuals with celiac disease because they don't have gluten.[3] They are also a significant source of dietary fiber, promoting gut health and aiding digestion.

Among its many nutritional attributes, finger millet stands out for its remarkable protein content, often exceeding other widely consumed grains, such as rice and wheat. However, the true essence of its nutritional prowess lies within the unique composition and properties of its constituent amino acids, building blocks of proteins. The nutritional richness of finger millets extends to their amino acid composition, which plays a pivotal role in determining the overall protein quality and biological value of these grains. As amino acids are the building blocks of proteins, understanding the chemistry involved in their structure, interactions, and transformations within finger millets becomes paramount for unlocking the full nutritional potential of these grains.

Finger millets, manifest a nutritional profile characterized by a mosaic of macronutrients and micronutrients.These grains are abundant in complex

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carbohydrates, contributing to sustained energy release and promoting satiety and contributing to their status as an energy-dense food source. Finger millets have a distinct nutritional composition, encompassing dietary fibers, B vitamins, and essential minerals such as calcium, iron, and phosphorus. Their nutritional density makes them an invaluable dietary component, especially in regions where access to diverse food sources may be limited.

The organochemistry of amino acids in finger millets encompasses the intricate web of chemical processes governing their synthesis, modification, and utilization within the plant. Amino acids not only contribute to the structural integrity of proteins but also serve as precursors for various bioactive compounds with potential health benefits. Exploring the amino acids in finger millets is not merely an academic pursuit; it holds practical implications for enhancing the nutritional content, digestibility, and bioavailability of proteins derived from these grains. Furthermore, such insights contribute to the development of sustainable agricultural practices, ensuring the cultivation of finger millets with optimized nutritional profiles to address the evolving needs of a growing global population and explore the formation of bioactive compounds, secondary metabolites, and their potential health-related implications. This not only contributes to global food security but also addresses prevalent health challenges associated with malnutrition and dietary deficiencies.

METHODOLOGY

An extensive review of scientific literature using databases such as Google Scholar, PubMed, Scopus, Research Gate and Academia was explored. Research that are relevant, research articles, and reviews focusing on the organochemistry of amino acids in finger millets were identified and information on methodologies, experimental designs, and key findings were compiled.

Amino Acid Composition

Amino acids, organic molecules characterized by an amine group, a carboxylic acid group, and a side chain, serve as the fundamental building blocks of proteins. These macromolecules are essential for virtually every aspect of human health and well-being, playing a critical role in protein synthesis, a complex biological process that underpins numerous physiological functions. The amino acid composition of finger millets (Eleusine coracana) is a complex interplay of essential and non-essential amino acids, contributing to the grains' nutritional richness. While the exact composition may vary slightly depending on factors such as cultivation conditions and varieties. Grain from finger millet can be processed in a variety of ways, depending on the final application. Various processing procedures are used to develop consumable products, including as flaking, debraning, popping, puffing, and malting [4]. They are crushed in a roller mill, like wheat, and win-mowed, to give coarse flour which is utilized as porridge. Similar to wheat, they are win-mowed and ground in a roller mill to produce coarse flour for porridge. Refined or whole grain flour is used in cakes, puddings, and porridges, as well as in regional Indian dishes such papad, dhebra, and bhakri. In addition to having a long shelf life, the flour is low in fat and gluten, easily absorbed, and requires minimal cooking [5].

About 5-8% protein, 1-2% ether extractives, 65 - 75% carbs, 15-20% dietary fiber, and 2.5–3.5% minerals are present in finger millet [6]. Out of all the cereals, it has the highest calcium concentration (344 mg/100 g). Phytates (0.48%), polyphenols, tannins (0.61%), trypsin inhibitory factors, and dietary fiber are also present in millet; these substances were formerly referred to be "anti nutrients" because of their ability to chelate metals and block enzymes, but they are now known as neutraceuticals. [7]. A rich source of phytochemicals including dietary fiber and polyphenols (0.2–3.0%), the millet seed coat is an edible part of the kernel [8,9]. It is now known that the antioxidant activity of millet foods, which is crucial for good health, aging, and metabolic disorders, can be influenced by phytates, polyphenols, and tannins. [10].

Protein synthesis involves the intricate assembly of amino acids into specific sequences dictated by genetic information. This process occurs within ribosomes, cellular structures that translate messenger RNA (mRNA) codons into corresponding amino acid sequences. The unique arrangement and interplay of these amino acids determine the resulting protein's three-dimensional structure, which ultimately dictates its function.

Finger millets possess a balanced composition of all the necessary amino acids., crucial for human health as they cannot be synthesized by the body.

Among these, lysine, an essential amino acid often deficient in cereal grains, is present in noteworthy amounts. This makes finger millet a valuable protein source, particularly for regions where lysine deficiency is prevalent. Finger millet grains, especially the seed coat, are rich in phenolic chemicals, notably benzoic acid derivatives, which have been shown to have antioxidant properties. [11-13]. Additionally, methionine and threonine, which are essential for protein synthesis and overall growth, are found in appreciable quantities. They also contain a spectrum of non-essential amino acids, including alanine, glutamic acid, and aspartic acid. These amino acids play essential roles in various metabolic processes, contributing to the overall functionality of proteins within the grains. Polyphenol content in white finger millet ranges from 0.04–0.09% on average, whereas brown cultivars have 0.08–3.47% [21]. Proto-catechuic acid (45.0 mg/100 g) was identified by Rao and Muralikrishna (2002) as the primary free phenolic acid in finger millet grains [5].

Proteins exhibit remarkable functional diversity, orchestrating a vast array of cellular processes, including:

- Structural support: Proteins like collagen and keratin provide structural integrity to tissues such as bones, skin, and hair.
- Enzymatic catalysis: Enzymes, composed entirely or partially of proteins, act as biological catalysts, accelerating essential metabolic reactions within the body.
- Immune function: Antibodies, crucial components of the immune system, are primarily composed of proteins and play a vital role in recognizing and neutralizing pathogens.
- Cellular signaling: Specific proteins act as signaling molecules, transmitting information between cells and coordinating various physiological responses.

The human body can synthesize some non-essential amino acids, but others termed essential amino acids, cannot be produced de novo and must be obtained through dietary sources. Deficiencies in these essential amino acids can have detrimental consequences, leading to:

- Muscle wasting: Inadequate protein intake can lead to muscle breakdown and impaired muscle function.
- Compromised immune function: Insufficient protein can hinder the production of antibodies, leaving the body vulnerable to infections.
- Stunted growth and development: In children, protein deficiencies can impede proper growth and development.

Essential Amino Acids:

1. **High Lysine Content**: Finger millets stand out for their elevated lysine content, surpassing many other cereal grains. Lysine, is a vital amino acid, which is necessary for the production of collagen, protein synthesis, and calcium absorption. The relatively higher concentration of lysine in finger millets addresses the frequent deficiency observed in traditional cereals, enhancing the nutritional quality of the protein.

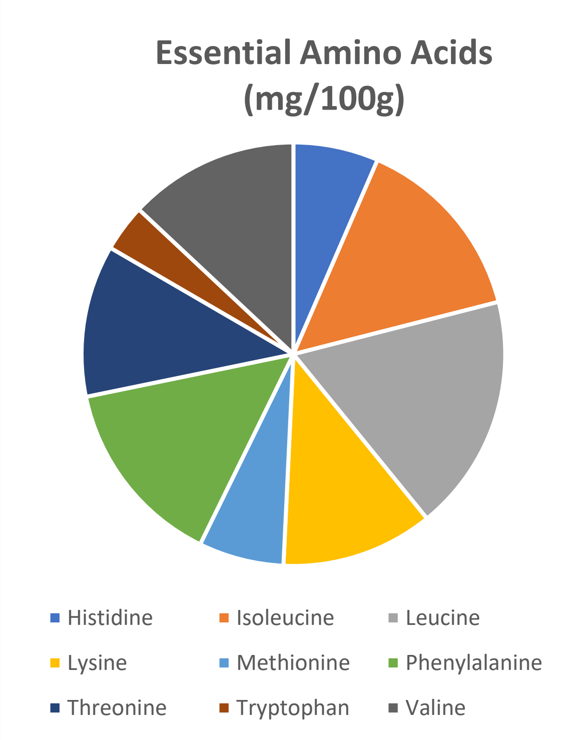
2. **Methionine and Threonine**: Finger millets demonstrate appreciable levels of methionine and threonine, both essential for protein biosynthesis and overall growth. The balanced presence of these amino acids contributes to the grains' potential as a nutritionally valuable protein source.

3. **Balanced Amino Acid Ratios**: Finger millets display a balanced ratio of essential amino acids, enhancing the overall protein quality. This balanced profile is particularly beneficial for populations relying on finger millets as a primary dietary staple, ensuring a more complete amino acid profile in conjunction with other food sources

Table 1: Essential Amino Acids (mg/100g)

Histidine	20-25
Isoleucine	45-55
Leucine	55-70
Lysine	35-45
Methionine	20-25
Phenylalanine	45-55
Threonine	35-45
Tryptophan	10-15
Valine	40-50

- **Leucine:** 55-70 (highest among essential amino acids in finger millet)
- **Lysine:** 35-45 (relatively lower compared to other essential amino acids)
- **Tryptophan:** 10-15 (lowest among essential amino acids)



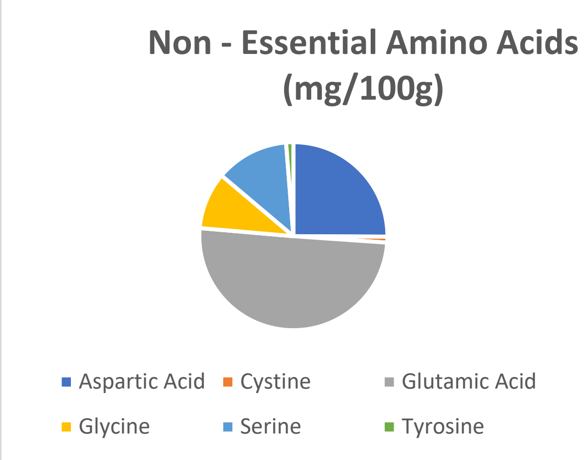
Histogram 1 between Essential Amino Acids and mg quantity

Non-Essential Amino Acids:

1. **Glutamic Acid**: Finger millets exhibit a notable content of glutamic acid, a non-essential amino acid pivotal in neurotransmission and as a precursor for glutathione, a vital antioxidant.
2. **Aspartic Acid and Alanine**: The grains contain measurable amounts of aspartic acid and alanine, contributing to various metabolic processes and protein functionality.
3. **Moderate Cysteine and Methionine Content**: Finger millets contain moderate levels of cysteine and methionine, sulfur-containing amino acids crucial for protein synthesis and contributing to the antioxidative capacity of the grains.

Table 2: Non-Essential Amino Acids (mg/100g)

Alanine	**400-500**
Aspartic Acid	800-1000
Cystine	30-40
Glutamic Acid	1600-2000
Glycine	300-400
Serine	400-500
Tyrosine	40-50



Histogram 2 between Non-essential amino acids and mg quantity

Table 3: Overall Nutritional Value of Finger Millets [16]

Cereal	Finger millet
Protein (%)	7.3
Fat (%)	1.3
Crude fibre (%)	3.6
Ash (%)	3.0
Starch (%)	59.0
Total dietary fiber (%)	19.1
Total phenol (mg/100 g)	102
Ca (%)	0.33
P (%)	0.24
K (%)	0.43
Na (%)	0.02
Mg (%)	0.11
Fe (%)	46.0
Mn (%)	7.5
Zn (%)	15.0
Thiamin (mg/100gm)	0.48
Riboflavin (mg/100gm)	0.12
Nicotinic acid (mg/100gm)	0.30

Finger Millet's Protein Content: A Comparison with Other Cereals

Finger millet, boasts a relatively high protein content compared to other commonly consumed cereals. While the exact amount can vary depending on various factors like variety, growing conditions, and processing, it generally falls within the range of 5-8%. This makes it one of the most protein-rich millets available. The essential amino acids methionine and lysine, which are critical for human development and health but are lacking in the majority of other plant diets, are more abundant in finger millet (McDonough et al., 2000). [17].

Table 4: Cereal Protein content comparison to Finger millet

Cereal	Cereal Protein content (per 100g)	Comparison to Finger Millet
Finger millet	5-8%	High
Wheat	12-14%	Higher, but gluten-containing
Rice	7-8%	Similar range, but is lower in essential amino acids
Maize (corn)	6-9%	Similar range, but lower digestibility
Barley	8-11%	Similar range, but is lower in certain essential amino acids
Oats	6-11%	Similar range, but higher in fiber and specific amino acids

Table 5: Strengths and Limitations of millets and cereals

Strengths and Limitations	
Strengths	Limitations
Comparing millets and cereals like rice and maize, finger millet boasts a higher protein content (5-8%).	Compared to other essential amino acids in finger millet, lysine content is relatively lower. This can limit the overall protein quality, especially for individuals with high lysine requirements. However, combining finger millet with lysine- rich sources like legumes can address this limitation.
Finger millet contains all nine essential amino acids, crucial for various functions in body. It has good amounts of isoleucine, leucine, valine, and phenylalanine, which can be limiting in other cereals.	Finger millet has a low tryptophan content which is essential for neurotransmitter production and requires dietary intake.
Finger millet protein shows better digestibility, making its essential amino acids more readily available for utilization by the body.	
They are richer in methionine and cystine compared to other cereals like rice and wheat. These sulfur-containing amino acids play vital roles in metabolism, enzyme function, and tissue building.	

Finger millet distinguishes itself from other cereals by containing relatively high amounts of sulfur-containing amino acids, namely methionine and cysteine. This characteristic makes it a valuable dietary source of these essential nutrients, often limiting in other commonly consumed grains.

Methionine and cysteine play crucial roles in various bodily functions, including

Protein synthesis: They are building blocks for protein formation, essential for tissue growth and repair. The presence of these essential amino acids improves the overall quality of finger millet protein, making it more bioavailable and readily utilized by the body.

- Metabolism: They participate in various metabolic processes, including energy production, detoxification, and fat metabolism.
- Antioxidant activity: They contribute to antioxidant defense mechanisms, protecting cells from damage.
- Enzyme function: They are involved in the activity of numerous enzymes necessary for various biochemical reactions.

Many commonly consumed cereals, like wheat, rice, and maize, are deficient in sulfur-containing amino acids. This can limit their overall protein quality and potentially lead to deficiencies if these amino acids are not obtained from other dietary sources. Finger millet can be combined with other protein sources like legumes, which are generally rich in lysine but low in sulfur-containing amino acids, creating a more complete protein profile.

Impact of Processing Techniques on Finger Millet's Amino Acid Profile and Digestibility

Processing techniques can significantly influence the amino acid profile and digestibility of finger millet, impacting its overall nutritional value.

1. Germination: It activates enzymes that break down complex molecules like phytates and tannins, which can hinder protein digestibility and amino acid bioavailability. It may slightly increase the free amino acid content due to the enzymatic breakdown of protein. However, the overall amino acid profile generally remains unchanged. Germination can significantly improve protein digestibility by reducing anti-nutritional factors and increasing protein solubility. Studies have shown an increase in pepsin and trypsin digestibility of finger millet protein after germination.

2. Fermentation: It involves microbial activity that can further degrade anti-nutritional factors and modify protein structure. Similar to germination, fermentation may lead to a slight increase in free amino acid content due to protein breakdown. Additionally, specific fermentation processes can potentially enrich the profile with certain amino acids through microbial synthesis. Fermentation can further enhance protein digestibility compared to germination by promoting protein hydrolysis and reducing anti-nutritional factors. Studies have reported improved in vitro digestibility and higher bioavailable lysine content in fermented finger millet compared to raw flour.

Factors like temperature, duration, and microbial strains employed can significantly impact the extent of changes in the amino acid profile and digestibility and combining germination and fermentation might offer synergistic effects, further improving protein utilization. Along with that accurately assessing changes in the amino acid profile and digestibility requires advanced analytical techniques like HPLC (High-Performance Liquid Chromatography) and in vitro digestibility assays.

Finger Millet: Potential Presence of Bioactive and Functional Amino Acids

1. **Dipeptides**:

Finger millet contains naturally occurring dipeptides formed by the linkage of two amino acids. These dipeptides, like carnosine and anserine, possess various potential health benefits, such as scavenging free radicals and protecting cells from oxidative damage and inhibiting the formation of advanced glycation end products (AGEs) linked to chronic diseases and potentially influencing nervous system function. They also supporting exercise performance and recovery, regulating blood sugar levels.

2. **Branched-chain amino acids (BCAAs):**

Finger millet contains leucine, isoleucine, and valine, collectively known as BCAAs. These amino acids play important roles in muscle protein synthesis and metabolism enhancing exercise performance and recovery: Promoting muscle growth and repair, reducing fatigue, and improving exercise endurance and influencing insulin sensitivity and glucose uptake. Finger millet might harbor bioactive peptides generated during processing, potentially exhibiting antimicrobial, immunomodulatory, and antihypertensive properties.

3. **Potential for bioactive peptide generation:**

During processing techniques like fermentation, microbial activity can generate bioactive peptides from finger millet proteins. These peptides might exhibit various functionalities such as inhibiting the growth of harmful bacteria, modulating the immune system's response and potentially lowering blood pressure. Compared to other cereals, finger millet generally contains lower levels of phytates and tannins, which can hinder protein digestibility.

Identifying and quantifying specific bioactive or functional amino acids in finger millet requires advanced analytical techniques like mass spectrometry and targeted peptide sequencing. Overall, finger millet possesses the potential for harbouring bioactive or functional amino acids with promising health benefits. However, further research is crucial to fully elucidate their presence, functionality, and potential impact on human health.

Organochemical Reactions

The organochemical landscape governing amino acid dynamics in finger millets (Eleusine coracana) presents a complex interplay of metabolic pathways, enzymatic reactions, and chemical transformations. A comprehensive examination of these processes is essential for a nuanced understanding of the molecular mechanisms dictating amino acid synthesis, modification, and interconversion within the matrix of finger millets.

Metabolic Pathways

Finger millets engage in multifaceted metabolic pathways orchestrating the biosynthesis of amino acids. The central hub for amino acid metabolism resides in the glycolysis and tricarboxylic acid (TCA) cycles. In finger millets, the carbon flux through these pathways converges on key intermediates such as pyruvate and α-ketoglutarate, serving as precursors for the biosynthesis of amino acids.

Biosynthetic Processes

Amino acid biosynthesis in finger millets spans multiple pathways, including but not limited to the shikimate, aspartate, and branched-chain amino acid (BCAA) pathways. The shikimate pathway, operating primarily in plastids, directs the synthesis of aromatic amino acids, while the aspartate pathway contributes to the formation of aspartate-derived amino acids. Branched-chain amino acids, crucial for protein synthesis and energy metabolism, are synthesized through dedicated pathways, further enhancing the complexity of amino acid biosynthesis in finger millets.

Enzymatic Reactions

Enzymatic orchestration governs the intricate transformations within amino acid metabolism. Key enzymes such as aminotransferases, dehydrogenases, and decarboxylases catalyze crucial steps in amino acid biosynthesis and interconversion. The specificity and regulation of these enzymes play a pivotal role in determining the abundance and profile of amino acids in finger millets.

Nitrogen Assimilation

The assimilation of nitrogen, a fundamental component of amino acids, occurs through pathways such as nitrate reduction and ammonia assimilation. Nitrate reductase and glutamine synthetase are central enzymes facilitating the conversion of nitrate to ammonium and its subsequent incorporation into amino acids. Understanding the regulation of these enzymes provides insights into the nitrogen utilization efficiency in finger millets.

Chemical Transformations

Beyond enzymatic reactions, finger millets undergo chemical transformations that extend the scope of amino acid metabolism. Post-translational modifications, including phosphorylation and acetylation, exert regulatory influence over enzymes participating in amino acid metabolism. Furthermore, the formation of secondary metabolites and bioactive compounds represents additional chemical transformations linked to amino acid dynamics, potentially influencing the nutritional and health-related attributes of finger millets

Health Implications

Finger millets are recognized for their polyphenolic content, including flavonoids and phenolic acids. The organochemical processes governing these compounds are intertwined with amino acid metabolism, potentially influencing antioxidant capacity and conferring health benefits. Besides these amino acid-derived alkaloids and terpenoids in finger millets contribute to the grains' bioactive arsenal. These compounds may exhibit pharmacological activities, impacting health parameters through mechanisms related to inflammation, oxidative stress, and immune modulation. Additionally, it has significant levels of α-linolenic acid and linoleic acid, two polyunsaturated fatty acids [18], metabolic products that support the central nervous system's healthy development. [19, 20]. Additionally, it includes tocopherols, thiamine, riboflavin, and niacin—all of which are water-soluble and liposoluble vitamins. [21].

1. **Antioxidant Properties**: The interplay between amino acid organochemistry and polyphenolic compounds in finger millets underscores their antioxidant potential. These antioxidants may mitigate oxidative stress, contributing to the prevention of chronic diseases and promoting overall health**.** Finger millet has a wide range of these chemicals, which may inhibit excessive cellular oxidation and shield against several malignancies that are common in the human population. Ferulic acid, the main component of bound phenolic acids in finger millet, has been shown to have a blocking impact on induced carcinogenesis in the tongue and colon of rats [22, 23], and in breast cancer cells [24] suggesting that it may function as a naturally occurring bioactive chemotherapeutic agent against cancer.

2. Cardiometabolic Health: Amino acids such as arginine and lysine, intricately linked to cardiovascular health, may influence vasodilation and blood pressure regulation. Finger millets, with their unique amino acid profile, hold promise in supporting cardiometabolic health. This is further corroborated by a recent study that found that feeding rats with high cholesterol intakes a multigrain diet that included finger millet as one of its constituents was beneficial in controlling their lipid and antioxidant metabolism [25]. Another affordable way to obtain essential metabolites for hypercholesteraemic treatment, such as sterol and statin, is through the fermentation of finger millet [26].

3. Anti-Inflammatory Effects:

Bioactive compounds derived from amino acid metabolism in finger millets, including alkaloids and terpenoids, may exhibit anti-inflammatory properties. This has implications for mitigating inflammatory conditions and promoting immune resilience.

4. Potential Nutraceutical Applications:

The convergence of amino acid organochemistry and bioactive compounds positions finger millets as potential sources of nutraceuticals. Tailoring cultivation practices to optimize specific amino acid profiles could yield functional food ingredients with targeted health benefits.

5. Anti Diabetic Effect

Food formulations and preparations made with finger millet have a lower glycemic index and glycemic response [27,28]. Two separate studies recommended reducing the incidence of type-2 diabetes by increasing dietary intake of calcium and magnesium. [29,30].

Because starch is less easily absorbed and digested, the presence of specific anti-nutritional components in whole finger millet fractions (such as phytates, tannins, and phenolics) may also aid to reduce the glycemic response. [31]. As a result, finger millet could be seen as a useful component for the treatment of diabetes and its aftereffects.

6. Improving Gut Health

Additionally, finger millet contains a high concentration of roughage, which is a combination of soluble and insoluble dietary fibers that resist breaking down during digestion and may help prevent diabetes, colon cancer, gastrointestinal diseases, and coronary heart disease [32]. Finger millet's insoluble fiber, which has a high cellulose content, functions as a laxative to promote bowel movement, bulks up stool, and prevents constipation by encouraging peristalsis and holding onto water in feces. Conversely, the soluble fibers help lubricate and soothe an inflammatory digestive tract. Together with the fibers, the polyphenols have anti-ulcerative properties and can aid in lowering gastric inflammation. [33]

It is a great source of protein (7–9%) and carbohydrates (80%) for those who are malnourished in terms of protein and energy, and it contains important amino acids like tryptophan, valine, and methionine that are otherwise rare in a vegetarian diet. Moreover, there is an abundance of vitamins, niacin, riboflavin, and thiamine, as well as minerals like potassium, calcium, phosphorus, and iron. Because finger millet has little fat, it is beneficial for obese individuals. In mouse models, supplementing with finger millet bran prevented obesity caused by a high-fat diet and enhanced the quantity of advantageous gut bacteria. [34]. This group of people also benefits from the carbohydrate component's slower digestion and prolonged absorption period. Eating food items made from this grain can lower excessive calorie consumption, raise the satiety index, and aid in weight loss.

7. Improving Bone Health

The second big worldwide health issue is osteoporosis. Taking traditional calcium mineral supplements can have unintended consequences [35] and could not be within the means of all societal segments. Increased consumption of naturally occurring calcium through diet helps prevent bone illnesses such as osteoporosis. With the seeds of finger millet containing up to 350mg/100g of calcium, which is 5–10 times more than other cereals, it is a reasonably decent source of the mineral. [36-38] In contrast, the average amount of calcium in 100 grams of cow's milk—a frequent source of calcium for many people—is 112 mg [39]. But unlike milk, it doesn't contain lactose sugar, which makes it a readily absorbed alternative food source for people with lactose intolerance and weaning infants. Therefore, goods made from finger millet can be used to help growing youngsters develop their bone mass as well as adults and the elderly population prevent osteoporosis and other bone diseases. Therefore, all of finger millet's nutritional value needs to be accurately translated into nutraceutical development and applied to other staple crops to potentially enrich them. [40].

Finger Millet: A Potent Source of Essential Amino Acids for Optimizing Human Health and Nutritional Status

Finger millet, a rising star in the realm of functional foods, presents a compelling case for its role in optimizing human health and nutritional status, primarily due to its exceptional content of essential amino acids. This analysis delves into the technical aspects of its amino acid profile and its potential health implications.

1. Complete Protein Source with Enhanced Bioavailability: Finger millet stands out as a complete protein source, containing all nine essential amino acids, which are indispensable for human health as they cannot be synthesized by the body. Notably, it exhibits significant levels of methionine, an often limiting amino acid in plant-based diets, crucial for protein synthesis, tissue repair, and detoxification. Additionally, the smaller protein size characteristic of finger millet facilitates superior digestibility compared to some other grains, leading to enhanced bioavailability and efficient absorption of essential amino acids by the body.

2. Muscle Protein Synthesis and Maintenance: Adequate intake of essential amino acids, particularly branched-chain amino acids (BCAAs) present in finger millet, is crucial for promoting muscle protein synthesis and maintaining muscle mass. This is particularly relevant for athletes, individuals recovering from injuries, and the elderly population.

3. Positive Nitrogen Balance: Finger millet protein, with its complete amino acid profile, can contribute to positive nitrogen balance, signifying the body's ability to retain nitrogen for tissue building and repair. This is particularly important for individuals at risk of protein deficiency, such as those with chronic illnesses or undergoing wound healing.

4. Immune Function Support: Essential amino acids play a vital role in supporting immune function by serving as precursors for immune cells and signaling molecules. Finger millet's complete amino acid profile can potentially contribute to a robust immune system.

Finger millet, presents a compelling nutritional profile that caters to various dietary needs, particularly for vegetarians and individuals seeking high-quality protein sources. This exploration delves into the scientific underpinnings of its potential benefits such as for Vegetarians it acts as Complete protein source it is relatively complete amino acid profile. Notably, it contains significant amounts of methionine, an often limiting amino acid in vegetarian diets. Methionine plays a critical role in protein synthesis, tissue repair, and detoxification. They undergo natural fermentation during processing, effectively breaking down complex molecules like phytates. This process enhances the bioavailability of essential minerals like iron and calcium, often poorly absorbed from plant-based sources. This is particularly beneficial for vegetarians who rely solely on plant-based sources for these crucial minerals. They are rich in dietary fiber, promoting gut health and satiety. It slows down digestion, leading to sustained energy levels and aiding in weight management. Finger millet is an excellent source of bioavailable calcium, essential for bone health and preventing osteoporosis. Calcium interacts with phosphate to form hydroxyapatite, the primary mineral component of bones and contains readily absorbable iron, essential for oxygen transport and red blood cell formation. Iron binds to heme, a molecule responsible for carrying oxygen in the blood. They are also rich in phenolic compounds and other antioxidants. These compounds scavenge free radicals, preventing oxidative stress and chronic diseases.

Interconnected Biochemical Pathways:

1. **Shikimate Pathway**: The shikimate pathway, responsible for the synthesis of aromatic amino acids, intersects with the production of phenolic compounds. This convergence creates a biochemical junction where amino acid precursors contribute to the formation of bioactive polyphenols in finger millets.

2. **Nitrogen Metabolism**: Nitrogen metabolism, vital for amino acid synthesis, is also intricately tied to the production of secondary metabolites. The balance between nitrogen assimilation and amino acid biosynthesis influences the levels of bioactive compounds, adding another layer of complexity to the interplay.

Gap in Research

A recurrent pattern across studies reveals the prominence of certain essential amino acids in finger millets, with lysine consistently standing out. This pattern underscores the nutritional significance of finger millets as a source of high-quality proteins. Moreover, studies consistently highlight the centrality of glycolysis and the TCA cycle in amino acid biosynthesis. The interconnectedness of these metabolic pathways showcases a pattern wherein key intermediates contribute to the synthesis of a diverse array of amino acids. There is a correlation emerges between the amino acid composition and the presence of bioactive compounds, particularly polyphenols. Studies consistently suggest that certain amino acid precursors contribute to the biosynthesis of bioactive polyphenolic compounds in finger millets.

Despite advancements, there remains a gap in mechanistic insights into specific organochemical reactions governing amino acid transformations in finger millets. Comprehensive elucidation of enzymatic pathways and regulatory mechanisms is crucial for a deeper understanding. The link between amino acid organochemistry and health implications in finger millets is an underexplored domain. Insufficient studies investigate the bioavailability, physiological effects, and potential nutraceutical applications of amino acids derived from finger millets. Few studies systematically address the impact of environmental factors on amino acid organochemistry. Considering the influence of factors like climate, soil composition, and agricultural practices is imperative for a holistic understanding.

RESULT AND DISCUSSION

Finger millet, a gluten-free grain gaining traction for its nutritional value, presents intriguing possibilities in the realm of targeted health benefits. Recent research delves into the potential interplay between its unique amino acid profile and specific health outcomes such as Gut Microbiome Modulation which explore the potential of finger millet's high branched-chain amino acid (BCAA) content to influence gut microbiota composition and function. This could have significant implications for gut health, immune function, and potentially metabolic regulation. More research is needed in understanding the role of finger millet protein and its constituent amino acids in modulating blood sugar levels and improving insulin sensitivity. This holds promise for individuals with diabetes or prediabetes, potentially offering a novel dietary approach. There are some studies that shows corelation between positive relation between ragi and cardiovascular health such as methionine and arginine, might influence cholesterol metabolism and blood pressure. Future studies should delve into the intricate regulation of amino acid metabolism in finger millets. Unravelling the regulatory mechanisms governing key enzymatic reactions and metabolic fluxes will contribute to a more nuanced understanding of organochemistry. A critical avenue for future research lies in exploring the health implications and nutraceutical potential of finger millet-derived amino acids and bioactive compounds. This includes in-depth studies on bioavailability, physiological effects, and targeted applications in preventive healthcare. Finger millet, with its unique amino acid profile, presents a compelling opportunity for scientific exploration. To fully understand the intricate interplay between its organic chemistry and potential health benefits, a multi-faceted research approach is necessary. Employing advanced analytical techniques like mass spectrometry and nuclear magnetic resonance (NMR) can comprehensively map the finger millet metabolome. This in-depth analysis would not only identify and quantify minor and modified amino acids, but also their derivatives. Such a comprehensive metabolic profile can provide invaluable insights into the potential health benefits associated with these lesser-known compounds. Conducting rigorous in vitro and in vivo studies is crucial to investigate the bioactivity and functionality of specific amino acids and their metabolites isolated from finger millet. This could involve meticulously assessing their antioxidant potential, impact on gut microbiota composition and function, and modulatory effects on cellular signaling pathways relevant to specific health outcomes. Moreover, exploring strategies to further enhance the bioavailability of finger millet amino acids holds immense potential. This could involve investigating the effects of fermentation techniques, enzymatic modification, and co-consumption with other food components on amino acid absorption and utilization by the human body. Delving into the synergistic interactions between finger millet amino acids and other bioactive components present in the grain, such as dietary fiber, phenolic compounds, and minerals, is essential for a holistic understanding. This comprehensive approach can shed light on the combined effects of finger millet on various aspects of human health. By pursuing these research avenues, this embark a journey to unlock the full potential of finger millet amino acid chemistry. This endeavor holds the promise of not only furthering scientific understanding but also paving the way for the development of innovative dietary strategies and functional food products tailored to address diverse nutritional need

CONCLUSION

Finger millets exhibit a distinctive amino acid profile, particularly enriched in essential amino acids, with a notable emphasis on lysine. It stands out as a crucial component addressing protein deficiencies, especially in regions where conventional cereals exhibit deficiencies in this essential amino acid. The identification of divergent findings and inconsistencies in amino acid quantities and bioactive compounds underscores the metabolic flexibility and adaptability of finger millets. Variability in responses to environmental conditions and cultivation practices hints at the grains' adaptability to diverse ecosystems. The recurring identification of glycolysis and the TCA cycle as central metabolic hubs underscores the interconnected nature of amino acid biosynthesis in finger millets. The utilization of key intermediates for the synthesis of diverse amino acids signifies a complex but orchestrated metabolic network. The correlation observed between amino acid composition and the presence of bioactive compounds, especially polyphenols, sheds light on the dual nutritional and health-promoting aspects of finger millets. This interplay suggests a potential synergy between amino acids and bioactive compounds in conferring health benefits. The synthesis of bioactive compounds from amino acid precursors accentuates the multifunctional significance of finger millets. Beyond providing essential amino acids, the grains contribute to antioxidant defenses, potentially mitigating oxidative stress-associated health challenges. Finger millets demonstrate nutritional resilience, particularly against lysine deficiency, positioning them as valuable dietary staples. Beyond nutritional aspects, the organochemistry of amino acids in finger millets holds implications for health, including antioxidant activities and potential nutraceutical applications. By critically analyzing findings, the review identifies patterns in amino acid composition and metabolic pathways while shedding light on inconsistencies and variabilities in reported results. The amino acid composition, notably the richness in lysine, positions finger millets as nutritional powerhouses. This resilience against lysine deficiency prevalent in other cereals is of paramount importance, especially in regions where these grains serve as dietary staples. The identification of gaps in health implication studies presents an opportunity for further exploration. Finger millets, with their unique amino acid and bioactive compound profiles, hold potential for nutraceutical applications. Targeted research in this direction can unveil specific health benefits and applications. Standardizing methodologies will not only improve the quality and reliability of research but also facilitate collaborative efforts and meta-analyses in the field. The critical analysis emphasizes the imperative for methodological standardization across studies. Harmonizing methodologies for sample collection, amino acid analysis, and other relevant techniques is essential to facilitate robust comparisons and meta-analyses. Combining data from genomics, transcriptomics, metabolomics, and proteomics will provide a more holistic understanding of the underlying biochemical processes.

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