A DISSERTATION ON

"Extraction and Nutritional Evaluation of Finger Millet Milk"

SUBMITTED TO THE
DEPARTMENT OF BIOENGINEERING
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IN PARTIAL FULFILMENT
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B.TECH.–M.TECH. DUAL DEGREE
IN
FOOD TECHNOLOGY

BY

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DECLARATION FORM

I, **Faizan Ullah Khan**, a student of **B.tech.–M.tech. Dual Degree Food Technology** (5th year /10th semester), Integral University have completed my six months dissertation work entitled **"Extraction and Nutritional Evaluation of Finger Millet Milk"** successfully from **Integral University** under the able guidance of **Prof. (Dr). Aisha Kamal**

I, hereby, affirm that the work has been done by me in all aspects. I have sincerely prepared this project report and the results reported in this study are genuine and authentic.

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CERTIFICATE

Certificate that Mr. **Faizan Ullah Khan** (Enrollment Number 1800101147) has carried out the research work presented in this thesis entitled **"Extraction and Nutritional Evaluation of Finger Millet milk"** for the award of **B.Tech.–M.Tech. Dual Degree Food Technology** from Integral University, Lucknow under our supervision. The thesis embodies results of original work and studies carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution. The dissertation was a compulsory part of his **B.Tech.–M.Tech. Dual Degree Food Technology** degree.

I wish him good luck and bright future.

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TO WHOM IT MAY CONCERN

This is to certify that **Faizan Ullah Khan** a student of **B.tech.–M.tech. Dual Degree Food Technology** (5th year/10th semester), Integral University has completed his six months' dissertation work entitled **"Extraction and Nutritional Evaluation of Finger Millet milk"** successfully. He has completed this work from **integral university** under the guidance of **Prof. Dr. Aisha Kamal** the dissertation was a compulsory part of his of **B.tech.–M.tech. Dual Degree Food Technology**

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ABBREVIATION

TAE	Total Tannins Content
GAE	Gallic Acid Equivalent
ML	Millilitres
GMO	Genetically Modified Organism
HRS	Hours
F	Fahrenheit
C	Celsius
RSM	Response Surface Methodology
μg	micro gram

ABSTRACT

This dissertation explores the potential of a variant of finger millet, GE-6834, as a valuable agricultural commodity. The study focuses on optimizing its yield and nutritional content through a series of pre-treatment techniques, including soaking and soaking with germination. Various combinations of soaking and germination durations are investigated, and statistical analysis, such as Regression Analysis of Variance, is employed to identify stable yield combinations. The best-performing yield combination is then further processed and stabilized. Proximate analysis is conducted to assess the nutritional composition of the optimized finger millet milk. A comparative study is carried out between finger millet milk and the well-known plant-based soy milk to evaluate their respective nutritional profiles and identify any superior attributes. Another critical aspect of this research involves the reduction of bioactive compounds known as antinutritional factors through germination techniques. Specifically, the study examines the extent to which antinutrients, such as phytic acid, polyphenols, and tannins, are reduced during the germination process.

Keyword - Finger Millet (GE-6834): Yield Optimization: Proximate Analysis: Comparative Study: Antinutritional Factors

INTRODUCTION

Millets, often referred to as "forgotten grains," are a diverse group of small-seeded grasses that have been cultivated for thousands of years. These hardy and resilient crops have played a vital role in the history and diets of many civilizations across the world. Despite their remarkable nutritional and environmental benefits, millets have recently been overshadowed by more popular cereal crops. However, as global awareness about health, sustainability, and food security grows, millets are regaining their well-deserved recognition.(1)(Shahidi & Chandrasekara, 2013).Millets belong to the Poaceous family, which also includes well-known cereal crops like rice, wheat, and maize. Unlike these major cereals, millets are highly adapted to diverse agroecological conditions, thriving in regions with low rainfall, high temperatures, and poor soil fertility. They are naturally pest and disease-resistant, requiring fewer chemical inputs for cultivation. This makes millet a sustainable and climate-resilient alternative to conventional cereal grains.(Saadat & Shukla, 2020).Millet is a group of small-seeded grasses that have been cultivated as staple crops for thousands of years. It belongs to the Poaceous family and is widely grown in various regions around the world, including Africa, Asia, and parts of Europe and America. Millet is known for its hardy nature, adaptability to diverse climates, and high nutritional value, making it an important food source for many communities.(Meena et al., 2021a).Historically, millets have been staple foods in many parts of the world, particularly in Africa and Asia. They have sustained communities in arid and semi-arid regions where other crops struggle to grow. Millets such as sorghum, pearl millet, finger millet, foxtail millet, and barnyard millet have nourished generations with their rich nutrient profile, including carbohydrates, dietary fibre, proteins, vitamins, and minerals.(Meena et al., 2021b).One of the most notable features of millets is their gluten-free nature, making them suitable for individuals with gluten sensitivity or celiac disease. Additionally, millets have a low glycaemic index, which means they release glucose into the bloodstream at a slower rate, helping regulate blood sugar levels. Their high Fiber content aids digestion, promotes satiety, and supports a healthy gut microbiome.(Taylor & Emmambux, 2008).Millets offer a diverse array of culinary possibilities. They can be used as whole grains, milled into flour, or even popped like popcorn.(Selladurai et al., 2023) They serve as versatile ingredients for various dishes, including bread, porridge, cakes, pancakes, soups, and even fermented beverages. Millet-based products are gaining popularity among health-conscious consumers looking for nutritious and gluten-free alternatives.(Mishra et al., n.d.).Furthermore, millets have a minimal water footprint compared to other cereal crops, requiring significantly less water for cultivation. Their short growing cycle and tolerance to drought conditions make them an attractive option in regions facing water scarcity and climate change challenges. The cultivation of millets also promotes biodiversity, as they provide habitats for beneficial insects and birds.(Wang et al., 2018).Efforts are underway to promote millet production, processing, and consumption to improve food security, sustainable agriculture, and nutritional diversity(Tripathi & Vyas, 2023). International organizations, governments, and NGOs recognize millet's potential in combating malnutrition, poverty, and climate change.(Jones, 2018).Millets are ancient grains with a remarkable nutritional composition and environmental resilience. They offer a sustainable solution to global challenges such as climate change, water scarcity, and food security. As we rediscover the value of these forgotten grains, millets are reclaiming their place on our plates and revitalizing agricultural systems for a healthier and more sustainable future.(S & B. Teli, 2023).The growing interest in plant-based milk alternatives has led to the rise of finger millet milk as a nutritious and sustainable option. However, finger millet contains anti-nutrients, such as phytates, tannins, and enzyme inhibitors, which can hinder the absorption of essential minerals and proteins. This research aims to explore innovative methods to diminish these anti-nutrients while enhancing the nutritional profile of finger millet milk. The presence of anti-nutrients in finger millet milk may impede its widespread acceptance as a viable alternative to soy milk and cow milk. Consequently, there is a pressing need to develop effective techniques to reduce anti-nutrient levels without compromising the nutritional benefits of finger millet milk.

Research Objective

- Extraction of milk from finger millet while altering its pre-treatment processing
- Evaluation of best variant of yield for finger millet milk
- Stabilization of finger millet milk
- Proximate and anti-nutritional analysis of the sample

REVIEW OF LITERATURE

2.1 Description of Some Commonly Known Types of Millet

2.1.1 Pearl Millet (Pennisetum Glaucum)

Pearl millet is one of the oldest cultivated grains and is primarily grown in Africa and India. It has a robust, tall stalk with a cluster of spike-like flower heads at the top. The seeds are small, round, and usually pale yellow or cream in colour(Jones, 2018). Pearl millet is a drought-tolerant crop and is often used in arid regions as a staple food. It is commonly used to make flatbreads, porridges, and alcoholic beverages.(Satankar et al., 2020)

2.1.2 Finger Millet (Eleusine Coracana)

Finger millet, also known as ragi, is widely grown in Africa and Asia. It is a short, annual grass with finger-like clusters of grain at the top. The seeds are small, reddish-brown, and densely packed. Finger millet is highly nutritious, rich in calcium, iron, and dietary Fiber. It is commonly used to make porridges, rotis (flatbreads), and various baked goods.(Devi et al., 2014a)

2.1.3 Foxtail Millet (Seteria Italica)

Foxtail millet is native to East Asia and is one of the oldest cultivated crops. It gets its name from the characteristic bushy appearance of its seed clusters, resembling a fox's tail.(Lata et al., 2013) The seeds are tiny, oval-shaped, and yellow or brown in colour. Foxtail millet is gluten-free and has a mild, nutty flavour. It is used in a variety of dishes, such as porridge, pilaf, salads, and even desserts. (Moon, M. 2016).

2.1.4 Proso Millet (Panicum Meliaceous)

Prose millet is native to Eurasia and has been cultivated for thousands of years. It has a relatively short stature, with a slender stem and bristly seed clusters. The seeds are small, round, and usually pale yellow or white. Prose millet has a mild, slightly sweet flavour and a soft texture. It is often used as a substitute for rice, in baking, and as bird feed.(Habiyaremye et al., 2017)

Proso millet (Panicum miliaceum L.) is a warm season grass with a growing season of 60–100 days. It is a highly nutritious cereal grain used for human consumption, bird seed, and/or ethanol production. Unique characteristics, such as drought and heat tolerance, make proso millet a promising alternative cash crop for the Pacific Northwest (PNW) region of the United States. Development of proso millet varieties adapted to dryland farming regions of the PNW could give growers a much-needed option for diversifying their predominantly wheat-based cropping systems. In this review, the agronomic characteristics of proso millet are discussed, with emphasis on growth habits and environmental requirements, place in prevailing crop rotations in the PNW, and nutritional and health benefits. The genetics of proso millet and the genomic resources available for breeding adapted varieties are also discussed. Last, challenges and opportunities of proso millet cultivation in the PNW are explored, including the potential for entering novel and regional markets.(Habiyaremye et al., 2017)

2.1.5 Barnyard Millet (Echinochloa Spp.)

Barnyard millet, also known as Sewa millet or Samvat rice, is cultivated in various parts of Asia. It has a tall, erect stem with long, slender seed spikes. The seeds are small, ovoid, and usually light brown or white. Barnyard millet has a mild, earthy flavour and a slightly chewy texture.(Devi et al., 2014b), It is commonly used in porridges, pilaf's, Upma (a Savory dish), and as a rice substitute.

These are just a few examples of the various types of millet cultivated and consumed around the world. Each millet variety has its unique nutritional profile, taste, and culinary applications, making them versatile and valuable food sources.

2.2 Selection of Finger Millet Variety Ge- 6834 For Milk Production

2.2.1 Nutritional Value

Finger millet is highly nutritious and packed with essential nutrients. It is rich in calcium, iron, dietary fibre, and several other minerals and vitamins. Research on finger millet can focus on analysing its nutrient composition, the bioavailability of nutrients, and potential health benefits associated with its consumption. (Devi et al., 2014c)

2.2.2 Health Benefits

Finger millet has been traditionally used for its medicinal properties. It is known to have antioxidant properties, which can help combat oxidative stress and reduce the risk of chronic diseases such as heart disease, diabetes, and certain cancers. Research can delve into the specific bioactive compounds present in finger millet and their impact on human health. (Kumar et al., 2016)

2.2.3 Gluten Free Grain

Finger millet is naturally gluten-free, making it an excellent alternative grain for individuals with gluten intolerance or celiac disease. Research can explore the potential of finger millet as a gluten-free staple and investigate its use in developing gluten-free food products. (Taylor & Emmambux, 2008b)

2.2.4 Sustainable Crop

Finger millet is a hardy crop that can thrive in diverse Agro-climatic conditions, including drought-prone regions. It requires minimal water and inputs compared to other staple grains. Research can focus on improving the productivity, resilience, and agronomic practices related to finger millet cultivation, contributing to sustainable agriculture and food security. (S. M. Gupta et al., 2017)

2.2.5 Indigenous Crop Preservation

Finger millet holds cultural and traditional significance in many regions where it is cultivated. Research efforts can concentrate on preserving and promoting finger millet cultivation to ensure the preservation of traditional knowledge and indigenous food systems. (Ruiz-Giralt et al., 2023)

2.2.6 Value-Added Products

Finger millet has a unique nutty flavour and versatile culinary applications. Research can explore the development of value-added products from finger millet, such as ready-to-eat snacks, bakery products, beverages, and fortified food formulations, thereby enhancing its market potential and diversifying food options. (Pragya Singh, 2012)

2.2.7 Climate Change Resilience

As finger millet is known for its adaptability to diverse environmental conditions, research can investigate its potential as a climate-smart crop. Studying the genetic traits of finger millet and its tolerance to environmental stresses can contribute to breeding programs aimed at developing climate-resilient crops. (S. M. Gupta et al., 2017)

By selecting finger millet for research, scientists and agricultural experts can uncover its full potential, ranging from nutrition and health benefits to sustainable farming practices and economic opportunities. Such research can further strengthen the understanding and utilization of this ancient grain, benefiting both human health and agricultural sustainability.

2.3 Superiority of Finger Millet Over Other Millets

Finger millet (Eleusine coracana) stands out as a superior millet variety compared to others due to its unique nutritional composition and potential health benefits. Here are some reasons why finger millet is considered superior to other millets:

2.3.1. Nutritional Composition

Finger millet has a more balanced and superior nutritional profile compared to other millets. It is rich in dietary fibre, protein, minerals (such as calcium, iron, and magnesium), and essential amino acids. Finger millet generally contains higher levels of these nutrients compared to other millets, making it a more nutritious choice. (Devi et al., 2014c)

2.3.2 Calcium Content

Finger millet is particularly noteworthy for its high calcium content compared to other millet varieties. Calcium is essential for maintaining strong bones, teeth, and overall skeletal health. Finger millet offers a valuable source of calcium, especially for individuals who may have limited access to dairy or other calcium-rich foods. (Pragya Singh, 2012)

2.3.3 Anti-Oxidant Properties

Finger millet is known for its potent antioxidant properties, attributed to the presence of various phytochemicals such as phenolic compounds and flavonoids. These antioxidants help combat oxidative stress and reduce inflammation in the body, potentially offering protective effects against chronic diseases. (Ofosu et al., 2020)

2.3.4 Gluten-Free

Finger millet is naturally gluten-free, making it suitable for individuals with gluten sensitivities or celiac disease. It provides a safe and nutritious alternative grain for those who need to avoid gluten-containing cereals like wheat, barley, and rye. (Patil et al., 2023)

2.3.5 Amino Acid Profile

Finger millet possesses a superior amino acid profile compared to other millet varieties. It contains higher levels of essential amino acids like methionine and cysteine, making finger millet protein more nutritionally balanced. This can be particularly beneficial for individuals following vegetarian or vegan diets, as it helps to address potential amino acid deficiencies. (Hassan et al., 2021)

2.3.6 Versatile Culinary Application

Finger millet is versatile in culinary applications and can be used to prepare a variety of dishes such as porridge, rotis, bread, cookies, and even beverages like finger millet milk. Its nutty flavour adds a unique taste to recipes and makes it a popular choice for both traditional and modern cuisine. (Patil et al., 2023)

2.3.7 Traditional and Cultural Significance

Finger millet has been an important staple crop in many regions for centuries. It has significant cultural and traditional value in various communities, and its cultivation and consumption contribute to the preservation of local food heritage and sustainable agriculture. (Lydia Pramitha et al., 2023) While finger millet offers these advantages, it's important to note that other millet varieties also provide nutritional benefits and have their own unique characteristics. The choice of millet depends on individual preferences, dietary needs, and availability. Incorporating a variety of millets into the diet can provide a diverse range of nutrients and promote overall dietary diversity and balance.

2.4 A Brief Study Comparing Millet Milk with Soy Milk

2.4.1 Soy Milk

Soy milk is a plant-based alternative to cow milk that is derived from soybeans. It is made by soaking, grinding, and boiling soybeans, followed by straining the mixture to remove the solids. The resulting liquid is a creamy, off-white beverage with a mild flavour.(Sethi et al., 2016)

2.4.1.1 Nutritional Composition

Soy milk is renowned for its nutritional profile. It is a good source of high-quality plant-based protein, containing all essential amino acids. Soy milk is also low in saturated fat and cholesterol-free. It provides carbohydrates, dietary fibre, vitamins (such as vitamin D, vitamin B12, and riboflavin), and minerals (including calcium, iron, and potassium). Many brands of commercially available soy milk are fortified with additional nutrients to enhance their nutritional value.(Hossen et al., 2022)

Nutritional value per 100 g Soymilk Energy, Kcal 67.0±0.5 52.0±0.5 Protein (g) 3.5±0.04 3.9±0.08 Fat (g)(Begum et al., 2016) Mean values of proximate analysis of soymilk. Parameters Mean values SD Moisture 88.25±2.00 Carbohydrates 2.4± 1.00 Crude fat 3.68±1.00 Crude fibre 1.10±0.50Ash 0.35±0.02NFE 2.35±1.15(Basharat et al., 2020)

2.4.1.2 Health Benefit

Consuming soy milk can offer several health benefits. Its high protein content makes it a suitable alternative for individuals following a plant-based or vegetarian diet. Soy protein has been linked to various health advantages, such as supporting heart health by reducing LDL cholesterol levels. Soy milk is also a good source of phytochemicals called isoflavones, which have been associated with potential health benefits, including reducing the risk of certain cancers, improving bone health, and alleviating menopausal symptoms in women.(Rizzo & Baroni, 2018)

2.4.2 Problems Related Soy Milk

While soy milk is a popular plant-based alternative to cow milk, it is important to be aware of potential problems or concerns associated with its consumption. Here are some issues related to soy milk:

2.4.2.1 Allergies and Sensitivities

Soy allergies are relatively common, and some individuals may experience adverse reactions when consuming soy milk. Symptoms can range from mild, such as hives or digestive discomfort, to severe, including difficulty breathing or anaphylaxis. It is essential for individuals with known soy allergies or sensitivities to avoid soy milk and seek alternative milk options.(Kattan et al., 2011)

2.4.2.2 Phytoestrogens

Soy contains compounds called phytoestrogens, specifically isoflavones, which are naturally occurring plant oestrogens. Some individuals may have concerns about the potential effects of phytoestrogens on hormone levels and their association with certain health conditions. However, the scientific evidence regarding the impact of phytoestrogens in soy on human health is still evolving, and the consensus is that moderate consumption of soy products, including soy milk, is safe and may even have health benefits. As with any dietary concerns, it is recommended to consult with healthcare professionals or registered dietitians for personalized advice.(Patisaul & Jefferson, 2010)

2.4.2.3 GMO Concerns

A significant portion of soybeans produced worldwide is genetically modified. This has raised concerns for some individuals who prefer to avoid genetically modified organisms (GMOs). If sourcing non-GMO soy milk is a priority, it is important to check labels or opt for organic-certified soy milk.(Sieradzki et al., 2021)

2.4.2.4 Digestive Issues

Soy milk contains oligosaccharides, a type of carbohydrate that can be difficult for some individuals to digest, leading to bloating, gas, or gastrointestinal discomfort. These issues are more likely to occur in individuals with irritable bowel syndrome (IBS) or other digestive conditions. Choosing a soy milk brand with reduced or eliminated oligosaccharides, or opting for other milk alternatives, may help alleviate these symptoms.(Mäkinen, 2016)

2.4.2.5 Thyroid Function

Soy contains compounds called goitrogens that can interfere with iodine absorption and potentially affect thyroid function. However, the impact of consuming moderate amounts of soy milk on thyroid health is generally considered to be minimal, especially in individuals with adequate iodine intake. If you have specific concerns about your thyroid health, it is advisable to consult with a healthcare professional.(Babiker et al., 2020)

2.5 Finger Millet Encounters Problems Arising from Soy Milk.

Finger millet (Eleusine coracana) can offer potential advantages in addressing certain problems associated with animal milk and soy milk. Here's how finger millet can counter some of these issues:

2.5.1 Allergies and Sensitivities

Unlike cow milk and soy milk, finger millet milk is not a common allergen and allergic reactions to it are rare. It can serve as a viable alternative for individuals with allergies or sensitivities to dairy or soy. (Kattan et al., 2011b)

2.5.2 Nutritional Profile

Finger millet is a highly nutritious grain that offers a range of essential nutrients, including proteins, dietary fibre, vitamins, and minerals. By consuming finger millet milk, individuals can benefit from these nutrients without relying solely on animal milk or soy milk. (Devi et al., 2014d)

2.5.3 Anti-Nutrients Reduction

Finger millet contains antinutrients like phytic acid, which can hinder the absorption of certain minerals. However, processing techniques such as soaking, germination, and fermentation can help reduce the antinutrient content in finger millet, thereby improving its nutrient bioavailability and making it a healthier alternative to soy milk. (Gowda et al., 2022)

2.5.4 Sustainability

Finger millet is a climate-resilient crop that requires minimal water and is well-suited for cultivation in various regions. Its cultivation and processing have a lower environmental impact compared to the livestock industry or soybean production. Choosing finger millet milk can contribute to sustainable and eco-friendly food choices. (Himalaya, n.d.)

2.5.5 Flavour and Culinary Versatility

Finger millet milk has a mild, nutty flavour that can be enjoyed on its own or used in various culinary applications. It can be incorporated into recipes for smoothies, desserts, baked goods, and Savory dishes, providing a unique taste and texture

2.6 Anti-Nutrients in Finger Millet: Types and Implications for Human Nutrition

finger millet is rich in essential nutrients, it also contains certain anti-nutrients, which are natural compounds that can interfere with nutrient absorption and utilization in the human body. Understanding these anti-nutrients is important to assess the overall nutritional value and potential health implications of finger millet consumption. Here, we will explore each anti-nutrient found in finger millet in detail

2.6.1 Phytates (Phytic Acid)

Phytates are the most well-known anti-nutrient in finger millet and various other plant-based foods.(Petroski & Minich, 2020) They are primarily found in the outer layer of the grain, also known as the bran. Phytic acid has a high affinity for minerals such as calcium, zinc, iron, and magnesium. When consumed, phytic acid can bind to these minerals, forming phytate-mineral complexes that are poorly absorbed by the human digestive system. This reduces the bioavailability of these essential minerals, leading to potential deficiencies, especially in individuals with diets heavily reliant on phytate-rich foods.(Gupta et al., 2015).To reduce the phytic acid content in finger millet and enhance mineral absorption, traditional processing techniques such as soaking, germination, and fermentation can be employed. These methods help to break down phytates, making the minerals more accessible for absorption during digestion.(Nkhata et al., 2018)

2.6.2 Tannins

Tannins are polyphenolic compounds found in various plant foods, including finger millet. They contribute to the astringent taste of some foods and beverages. In finger millet, tannins can bind to proteins and interfere with their digestion. (Sharma et al., 2021)Additionally, tannins can also complex with minerals like iron, reducing their absorption. However, the levels of tannins in finger millet are relatively low compared to some other grains.(Puranik et al., 2017).While tannins may have anti-nutrient properties, they also possess antioxidant properties and can provide health benefits when consumed in moderation.(Puranik et al., 2017)

2.6.3 Oxalates

Finger millet contains oxalates, which are naturally occurring compounds found in certain vegetables and leafy greens as well. Oxalates can bind to calcium, forming calcium oxalate crystals, which are not readily absorbed by the body. This can potentially lead to reduced calcium absorption and increase the risk of kidney stone formation in individuals prone to kidney stones.(Radek & Savage, 2008).It is worth noting that the levels of oxalates in finger millet are relatively low, and unless consumed in very high quantities, they are unlikely to pose a significant health risk for most individuals.(Petroski & Minich, 2020)

2.6.4 Enzyme Inhibitors

Finger millet contains enzyme inhibitors that can interfere with the digestion of proteins and carbohydrates. These inhibitors can slow down the activity of certain digestive enzymes, affecting the breakdown of proteins and carbohydrates into absorbable forms. While enzyme inhibitors may hinder some digestive processes, they are typically inactivated by cooking or other food processing methods.(Gong et al., 2020)

2.7 Pasteurisation

Pasteurization is a widely used food processing technique aimed at destroying harmful microorganisms (such as bacteria, viruses, and yeasts) in food products to improve safety and extend shelf life. Named after its inventor, Louis Pasteur, this process involves heating a liquid or food product to a specific temperature for a set period, followed by rapid cooling to eliminate pathogens without significantly altering the taste or nutritional content of the product. Pasteurization plays a crucial role in ensuring food safety and preserving the quality of various food items, including dairy products like milk.(Fellows, 2022)

2.7.1 Techniques of Pasteurization

There are several techniques of pasteurization, each tailored to specific food products. For dairy products like milk, the most common techniques include:

2.7.1.1 High-Temperature Short-Time Pasteurization

In this method, milk is rapidly heated to around 161°F (71.7°C) for about 15 seconds, followed by immediate cooling. HTST pasteurization is widely used for its efficiency in killing harmful bacteria while minimizing heat-induced damage to the product.(Fellows, 2022)

2.7.1.2 Ultra-High-Temperature Pasteurization

UHT pasteurization involves heating milk to temperatures exceeding 275°F (135°C) for a few seconds, effectively eliminating nearly all microorganisms. This process results in milk that can be stored at room temperature for an extended period, provided it is sealed in a sterile container.(Fellows, 2022)

2.7.1.3 Low-Temperature Long-Time (Ltlt) Pasteurization

LTLT pasteurization employs lower temperatures (around 145°F or 63°C) for a longer duration, typically 30 minutes. This method is often used for specialty dairy products like cheese.(Fellows, 2022)

2.8 Homogenization

Homogenization is a crucial step in the dairy industry, especially for milk processing. It is a mechanical process that breaks down and disperses fat globules in milk to create a uniform and stable mixture. This prevents the separation of cream from the milk and enhances the texture, taste, and appearance of dairy products.(Patel et al., 2015)

2.8.1 Techniques of Homogenization

Homogenization is achieved through a high-pressure mechanical process that forces milk through a small nozzle or homogenizer. The two primary techniques are

2.8.1.1 High Pressure Homogenisation

In this method, milk is forced through a narrow valve at high pressure (often several thousand pounds per square inch). The intense pressure causes fat globules to break down into smaller sizes, creating a more uniform distribution in the milk.

2.8.1.2 Ultrasonic Homogenisation

Ultrasonic waves are used to create high-frequency sound waves that agitate and break down fat globules. This technique is less common but offers some advantages in terms of energy efficiency.

MATERIAL AND METHOD

3.1 Utensils Utilized in Finger Millet Milk Processing

Table 1 Utensils Utilized in Finger Millet Milk Processing

Apparatus	Volume	Company
Beakers	100ml,250ml,	Borosil
Gerber Tube	10ml	Borosil
Flask	250ml	Borosil
Burette	50ml	Borosil
Pipette	25ml	Borosil
Kjeldahl Digestion Flask	100ml	Foss
Measuring Cylinder	500ml	Borosil

Instruments	Company
Protein Analyser	Foss
Fat Analyser	Foss
Electrical Heating Plate	Labsol
Magnetic Stirrer	Foss
Grinder	Prestige
Refrigerator	Kirsch
Weighing Scale	Aczet
Thermometer	Borosil
Ice Water Bath	Kelvin
Desiccator	Garg Glass
Silica Crucile	Swastik
Muffle Furnace	Presto Stantest

Table 2 Reagents and Materials

Reagents	Materials
NaOH,	Distilled Water
Concentrated Sulphuric Acid	Muslin Cloth
Sodium Hydroxide Solution	Filter Papper
Methyl Red Indicator Solution	Petri-Dish
Amyl Alcohol	Bloating Pappers
Gerber Sulphuric Acid	
Iso-Amyl Alcohol (C5h11oh)	
Folin - Ciocalteu	

3.2 Millet Milk Processing Methods

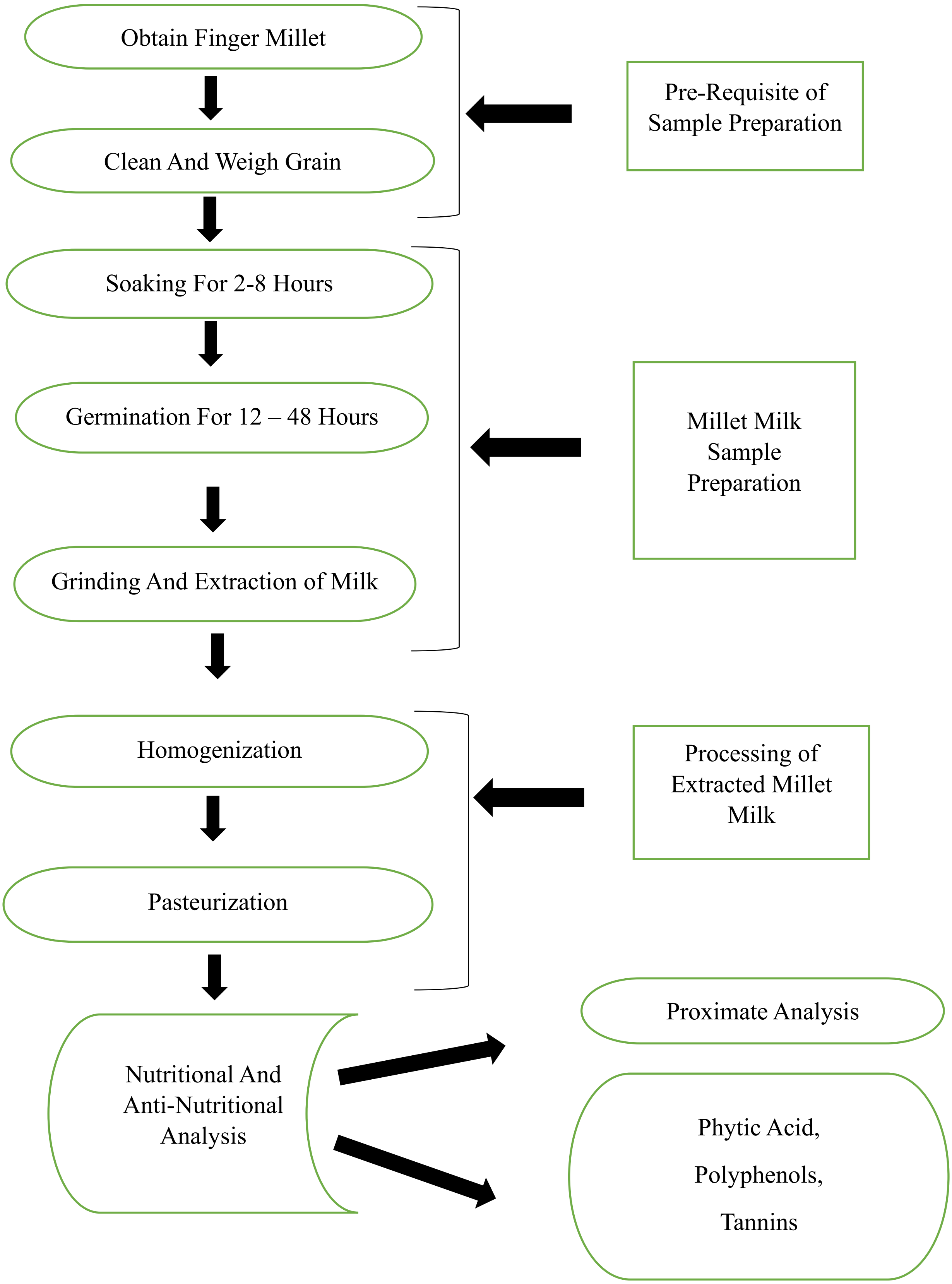

Figure 1 Flow chart of finger millet milk extraction and processing method

3.3 Selection and Preparation of Finger Millet

3.3.1 Pre -Preparation of Sample

The Finger Millet, purchased from a reliable source like Big Basket or local market, underwent meticulous washing to ensure its cleanliness. Careful sorting was performed to eliminate any unwanted and broken kernels from the batch. To optimize the millet milk extraction process, Soaking and germination times were standardized using Response Surface Methodology (RSM) with a central composite design. This experimental approach yielded 21 combinations to determine the ideal soaking time (ranging from 4 to 8 hours) and germination time (spanning 12 to 48 hours).

3.3.2 Cleaning and Weighing Finger Millet Grains

To prepare a sample of finger millet grains for soaking and germination, a series of steps are followed. First, ensure that you have 100 grams of finger millet grains. Then, the grains are sorted to remove any discoloured, damaged, or shrivelled ones to ensure only healthy grains are used. Next, the sorted 100 grams of grains are rinsed thoroughly under running water to remove dirt and debris. After rinsing, they are transferred to a container and soaked in clean water for 8 to 10 hours or overnight to initiate the germination process. Following the soak, the water is drained using a sieve or strainer, and the grains are allowed to air dry on a tray or clean surface for several hours to reduce excess moisture and prevent fungal growth. Finally, the dried grains are weighed for precise measurements during the soaking and germination process. These steps collectively prepare the 100 grams of finger millet grains for optimal soaking and germination conditions.

3.4 Processing and Extraction of Milk

3.4.1 Soaking

Soaking finger millet is a simple yet crucial process that involves submerging the millet grains in water for a specific period, typically ranging from 2 to 8 hours. During this time, the grains absorb water, which softens their outer layer and initiates various beneficial changes. As the millet soaks, it becomes easier to cook and digest. Additionally, soaking helps reduce antinutrients like phytic acid, enhancing the availability of essential nutrients like minerals. The duration of soaking can vary based on the desired texture and recipe requirements. Shorter soaking times (around 2 hours) are suitable for a slightly firmer texture, while longer soaking (8 hours) results in softer millet,.(Devi et al., 2014a)

3.4.2 Germination

germination of finger millet involves a multi-step process, typically spanning from 12 to 48 hours, designed to harness the beneficial effects of sprouting. After soaking the finger millet grains, they are placed in a muslin cloth or a similar breathable material. During this period, the grains are kept consistently moist by periodically spraying them with water every 2 to 3 hours. The objective of germination is to allow the millet grains to sprout tiny shoots. This process triggers enzymatic changes and neutralizes antinutrients like phytic acid, making the millet more nutritious and easier to digest.(Kumar et al., 2021).

3.4.3 Grinding

The next step in the process after soaking and germination of finger millet involves grinding the millet to create a smooth mixture. To do this, 200 ml of water is added to the soaked and germinated millet, and then a grinder is used to blend them together until the mixture achieves a smooth consistency.(Prasad & Kumar, 2014).

3.4.4 Extraction of Milk

After grinding the finger millet mixture, the next step is to extract the finger millet milk sample. This extraction process is carried out using a muslin cloth and sieve. The ground mixture is placed in the muslin cloth, and gradual pressure is applied to squeeze out the millet milk. This continues until there is no liquid left inside the cloth. The extracted millet milk is carefully collected in a measuring cylinder, and readings are recorded for measurement and analysis purposes. Subsequently, the collected millet milk is transferred to an airtight container. To maintain its freshness and quality, the container is sealed tightly, and the millet milk is stored in a refrigerator for further analysis.(Shobana & Malleshi, 2007).

3.4.5 Method of Calculating Yield Percentage

First, obtain the yield (X) by grinding 100 grams of soaked and germinated finger millet grains with 200 ml of water. Calculate the total weight of the mixture, which includes both the grain and water. In this case, it is 100 grams (grains) + 200 ml (water) = 300 grams. Now, use the formula to calculate the yield percentage(Singh Chauhan & Sarita, 2018)

Yield Percentage = (X / Total Weight) * 100

Yield Percentage = (X / 300) * 100

3.5 Processing and Stabilization of Finger Millet Milk

3.5.1 Homogenization

To prepare finger millet milk, start by soaking and blending the finger millet grains. After blending, strain the mixture to obtain the milk. Allow the strained finger millet milk to sit undisturbed for a while, which helps larger particles or sediments settle at the bottom of the container, facilitating the removal of any coarse particles before homogenization. Carefully transfer the finger millet milk to a clean blender or food processor, leaving some space at the top for expansion during blending. Begin the blending process at low speed and gradually increase to higher speeds to break down fat molecules and achieve a smoother consistency. Typically, 1 to 2 minutes of high-speed blending should suffice, but adjust as needed. After blending, check the consistency, which should appear smoother and more uniform than before blending. Finally, transfer the homogenized finger millet milk to a clean container, being mindful not to transfer any settled coarse particles from the blender.(Olodo et al., 2020)

3.5.2 Pasteurization

To pasteurize finger millet milk, start by preparing a double boiler or a large pot with water, which will act as an indirect heat source to prevent scorching. Pour the homogenized finger millet milk into a clean, heat-resistant container, leaving some space at the top to avoid spillage. Begin heating the water in the bottom pot or the large pot over medium heat. Insert a cooking thermometer into the finger millet milk, ensuring it's submerged but not touching the container's bottom. Gradually heat the milk while continuously monitoring the temperature, aiming to reach 161°F (72°C). Once this temperature is achieved, maintain it for 15 seconds to effectively pasteurize the milk and eliminate harmful microorganisms. After pasteurization, remove the container from the heat source and rapidly cool it down using an ice water bath or let it cool at room temperature. Once cooled, transfer the pasteurized finger millet milk to clean, sterilized containers, and seal them tightly to prevent contamination.(Fellows, 2022)

3.6 Proximate Analysis of Processed Finger Millet Milk

Proximate analysis will be conducted to determine the major nutrients present in milk type. This analysis will include assessing the moisture content, protein, fat, carbohydrates, ash, and crude fibre in finger millet milk, The FSSAI (Food Safety and Standards Authority of India) manual for milk and milk products will be employed as a reference for conducting the proximate analysis.

3.6.1. Protein Analysis

The protein analysis involves several steps and the use of specific equipment and reagents. Firstly, a 500 or 800 ml Kjeldahl digestion flask is used, and the sample (1-2 g) is weighed and transferred into the flask along with 0.7 gm of Mercuric oxide, 15 gm of Potassium Sulphate, and 40 ml of concentrated Sulphuric acid. The flask is placed in an inclined position and heated gently until the mixture boils steadily and turns pale blue. After cooling, 200 ml of water is added, and the mixture is made strongly alkaline by adding Sodium Hydroxide solution (450gm/litre). The digest is then connected to a distillation apparatus, and 150 ml of distillate is collected in a conical flask with 5 drops of methyl red indicator. Titration with 0.1 N Sodium Hydroxide solution is performed, and a blank titration is carried out simultaneously. The protein content is calculated as N x 6.25, and protein on a dry weight basis is determined by multiplying the protein content by 100 and dividing by (100 - Moisture content). The 6.25 factor is commonly used for protein calculation when the nature of the protein is unknown or when analysing a mixture of different proteins with different factors, providing valuable insights into the protein content of the sample.(*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

Protein % (on dry basis) = [(nitrogen content x 6.38) / weight of the milk sample(g) - moisture content of the milk sample(g))] x 100

3.6.2 Fat Analysis

The Gerber method is employed to determine fat content in milk. This process involves mixing milk with sulphuric acid and iso-amyl alcohol within a specialized Gerber tube, facilitating protein dissolution and fat release. Following centrifugation, the fat ascends into the calibrated section of the tube, and its percentage in the milk sample is measured. This method serves as a routine or screening test, offering reproducible results if executed correctly. Reagents and apparatus required for this method include sulphuric acid with specific density, furfural-free amyl alcohol, Gerber sulphuric acid, and iso-amyl alcohol. The Gerber butyrometer, pipettes, lock stoppers, a water bath maintained at 65 ± 2°C, and a Gerber centrifuge are used in the procedure. The process involves precise steps, including measuring sulphuric acid, gently mixing the milk sample, filling the butyrometer tube, adding amyl alcohol, closing with a lock stopper, and shaking for homogeneity. After a water bath and centrifugation, the fat percentage is read and recorded accurately. This empirical method offers reliable results when properly followed, making it valuable for determining milk fat content.(*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

1.12 X 10 -6 effective horizontal radius in mm x speed in revolutions per min (2)

3.6.3 Moisture Content Analysis

The moisture content in the sample is determined by drying it to a constant weight at 102 ± 2°C, following the method specified in IS 16072:2012. The procedure begins by placing a dish and its lid in a hot air oven at 102 ± 2°C for 1 hour, followed by cooling in a desiccator and subsequent weighing. Approximately 1 g of the dried milk sample is then placed in the dish, covered with the lid, and accurately weighed. The dish is uncovered and returned to the 102 ± 2°C hot air oven for 2 hours. After cooling and weighing in the desiccator, the uncovered dish and lid are heated in the hot air oven for an additional 1 hour, followed by cooling and weighing. This process of drying, cooling, and weighing is repeated until successive weighing show a difference of no more than 0.5 mg, with complete drying typically achieved after the initial 2-hour period.(*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

$$\textbf{Moisture \% by mass} = \frac{\mathbf{100(initial\ mass(g) - final\ mass(g))}}{\mathbf{initial\ mass(g) - mass\ of\ empty\ dish(g)}}$$

3.6.4 Carbohydrate Analysis

Add moisture, fat, protein and ash content and deduct the value from 100 to give carbohydrate content by difference. Total carbohydrate including sucrose, dextrose and dextrin, maltose or lactose percent (*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

Carbohydrate weight = 100 – (Percent by mass of moisture + Percent by mass of total protein + Percent by mass of fat and + Percent by mass of Total ash)

3.6.5 Crude Fiber Analysis

The analysis procedure, dilute sulfuric acid (1.25% W/V) and sodium hydroxide (1.25% W/V) solutions are prepared accurately. About 5 g of the material is dried to a constant weight in an air oven at 105 ± 2°C. Approximately 2.5 g of the dried material is weighed accurately and placed into a thimble for extraction with petroleum ether using a Soxhlet flask for one hour. The fat-free material is then transferred to a 1-liter flask. In a separate beaker, 200 ml of diluted sulfuric acid is brought to a boil and immediately poured into the flask containing the fat-free material. The flask is connected to a reflux condenser and heated so that boiling begins within a minute. The flask is rotated frequently to prevent material from sticking to the sides and to ensure contact with the acid. Boiling continues for exactly 30 minutes. Afterward, the flask is removed, and the mixture is filtered through fine linen, washed with boiling water until the washings are no longer acidic to litmus. Next, 200 ml of sodium hydroxide solution is brought to a boil under reflux condenser, and the residue on the linen is washed into the flask with the boiling sodium hydroxide solution. The flask is immediately connected to the reflux condenser and boiled for exactly 30 minutes. After boiling, the flask is removed, and the mixture is filtered through a filtering cloth. The residue is thoroughly washed with boiling water and then transferred to a Gooch crucible prepared with a thin compact layer of ignited asbestos. The residue is washed thoroughly again, first with hot water and then with 15 ml of ethyl alcohol. The Gooch crucible with its contents is dried in an air oven at 105 ± 2°C until a constant weight is achieved. Subsequently, it is incinerated in a muffle furnace until all carbonaceous matter is burnt. After cooling in a desiccator, the final weight is recorded for analysis.(*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

$$\textbf{Crude Fibre (dry basis)} = \frac{\textbf{Mass of gooch(g)} - \textbf{mass of gooch crucible containing ash}}{\textbf{Mass dried material taken for test(g)}} * \mathbf{100}$$

3.6.6 Ash Content Analysis

Weigh accurately about 3 g of the dried milk sample in the crucible, previously dried in a hot air oven and weighed. Heat the crucible gently on a burner or hot plate at first and then strongly in a muffle furnace at 550°C till grey ash is obtained. Cool the crucible in a desiccator and weigh it. Heat the crucible again at 550°C for 30 min. Cool the crucible in a desiccator and weigh. Repeat this process of heating for 30 min, cooling and weighing until the difference between two successive weighing is less

than 1 mg. Record the lowest mass.(*MANUAL OF METHODS OF ANALYSIS OF FOODS FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA MINISTRY OF HEALTH AND FAMILY WELFARE GOVERNMENT OF INDIA NEW DELHI 2016 CEREAL AND CEREAL PRODUCTS*, n.d.)

$$\textbf{Total ash (in dry basis) \% by mass} = \frac{\textbf{Mass of crucible with ash(g)} - \textbf{Massof empty crucible(g)}}{(\mathbf{100} - \textbf{Moisture}) * (\textbf{Mass of material(g)} - \textbf{Mass of empty crucible})} * \mathbf{100}$$

3.7 Anti-Nutritional Analysis of Processed Ge-6834 Finger Millet

3.7.1 Phytic Acid Analysis

The determination of phytic acid involved the extraction of phytate using trichloroacetic acid and subsequent precipitation as a ferric salt. The iron content of the resulting precipitate was quantified through a colorimetric method, allowing for the calculation of phytate phosphorus content. This calculation assumed a consistent 4:6 molecular ratio in the precipitate. Phytates were assessed both as phytic acid and phytate phosphorous(Shig Halli et al., 2018).

Phytate P (mg/100g) = (µg Fe × 15 × 1 / Wt. of sample (g)) × (1 / 100)

3.7.2 Polyphenols and Tannins Analysis

Total polyphenols and total tannin content were assessed using the Folin – Ciocalteu reagent, following the method described by Swain and Hillis in 1959 (Swain & Hillis, 1959). The quantification was accomplished by establishing standard calibration curves using gallic acid (ranging from 0 to 0.1 mg/ml) for total polyphenols and tannic acid (ranging from 0 to 0.1 mg/ml) for total tannins. The results were reported as milligrams of gallic acid equivalents per gram of dry weight (mg GAE/g DW) for total polyphenols and as milligrams of tannic acid equivalents per gram of dry weight (mg TAE/g DW) for total tannin content.

RESULT AND DISCUSSION

4.1 Finger Millet Milk Yield Obtained at Different Soaking and Germination Combinations

Table 3: Yield Obtained At 12 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/12	178	59.33
6/12	186	62
8/12	182	60.66

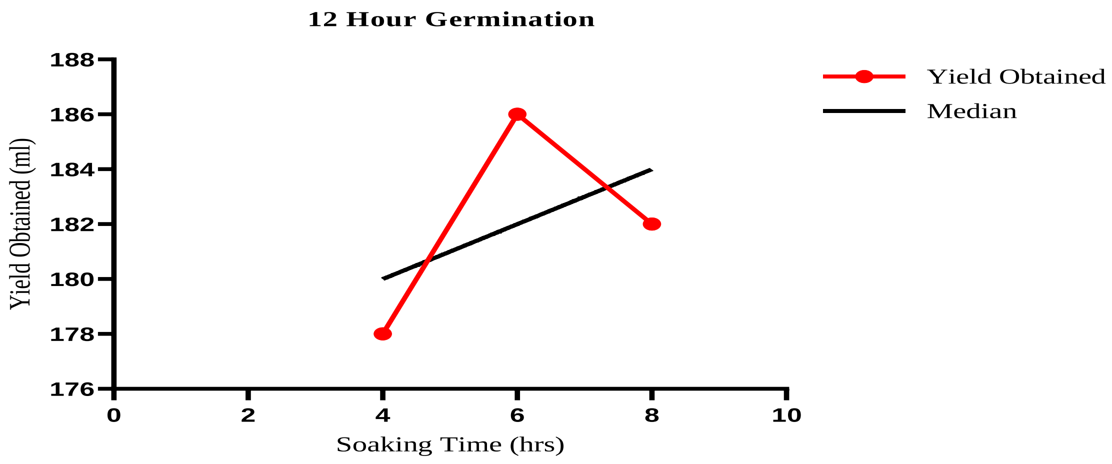

Figure 2: 12 Hours Germination

We have some interesting data that shows how the amount of finger millet milk we get changes with different soaking times. This is important because soaking and germination can affect the properties of the finger millet and the milk, we obtain from it. When we soaked the finger millet for 4 hours, we got about **178 ml (59.33%)** of milk. Then, when we increased the soaking time to 6 hours, the milk yield went up to **186 ml (62%).** This seems like a good increase, suggesting that a longer soaking time might be better. However, when we extended the soaking time to 8 hours, the yield actually went down a bit to **182 ml (60.66%).** This is interesting and might be due to some factors. One possibility is that the temperature and humidity conditions during the longer soaking time might have fluctuated a bit, even though we tried to control them. Sometimes, small changes in these factors can affect the germination process and the milk yield. It's like when you're baking something in the kitchen if the temperature isn't exactly right, the result can be different. Similarly, the finger millet might be sensitive to these variations during soaking and germination. So, even though we saw a rise in milk yield from 4 to 6 hours of soaking, the slight dip at 8 hours could be because of these fluctuations in temperature and humidity. While we tried our best to control everything, there's always a tiny room for error. To make sure we really understand what's happening, we might want to repeat these experiments a few more times and see if we consistently get similar results. This way, we can confirm whether the trend of increasing yield up to 6 hours and then a slight decrease at 8 hours is really happening. In science, it's important to consider all the factors that can affect our results, even the small ones like temperature and humidity. By gathering more data and being careful with our experiments, we can get a clearer picture of how soaking time affects the yield of finger millet milk.

4.1.2 Table 4: Yield Obtained At 18 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/18	166	55.33
6/18	168	56
8/18	178	59.33

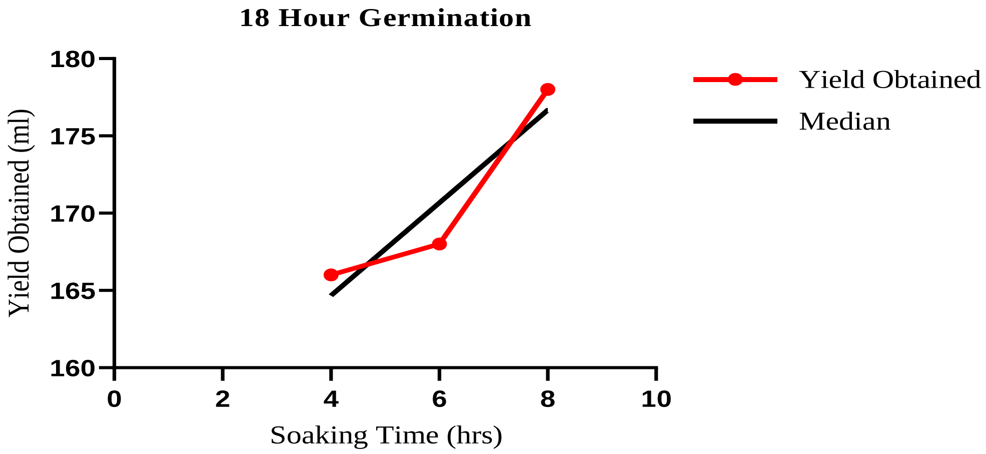

Figure 3: 18 Hours Germination

In this set of data, we extended the germination time to 18 hours and observed its impact on finger millet milk yield. This follows our previous investigation into soaking and germination times. At 4 hours of soaking and 18 hours of germination, we obtained a yield of **166 ml (55.33%).** As we increased the soaking time to 6 hours, the milk yield also went up slightly to **168 ml (56%).** Interestingly, when we soaked for 8 hours, we saw a more noticeable increase in yield to **178 ml (59.33%).** Comparing this to our earlier findings with shorter germination times, a trend seems to emerge. Just like before, a longer soaking time (8 hours) led to a higher yield compared to shorter soaking times (4 and 6 hours). This could imply that the finger millet benefits from a more extended time to undergo the germination process. However, it's important to remember that small variations in environmental conditions, such as temperature and humidity, might still be playing a role in these results. These fluctuations, even though we try to control them, can lead to slight changes in the germination process and, consequently, the milk yield. To get a clearer understanding of this trend, conducting more trials with varying germination times and closely monitoring the environmental factors could help solidify the relationship between germination time and finger millet milk yield. This data adds to our understanding of how time affects the nutritional composition of finger millet and its potential applications in food preparation.

Table 5: Yield Obtained At 24 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/24	174	58
6/24	174	58
8/24	178	59.33

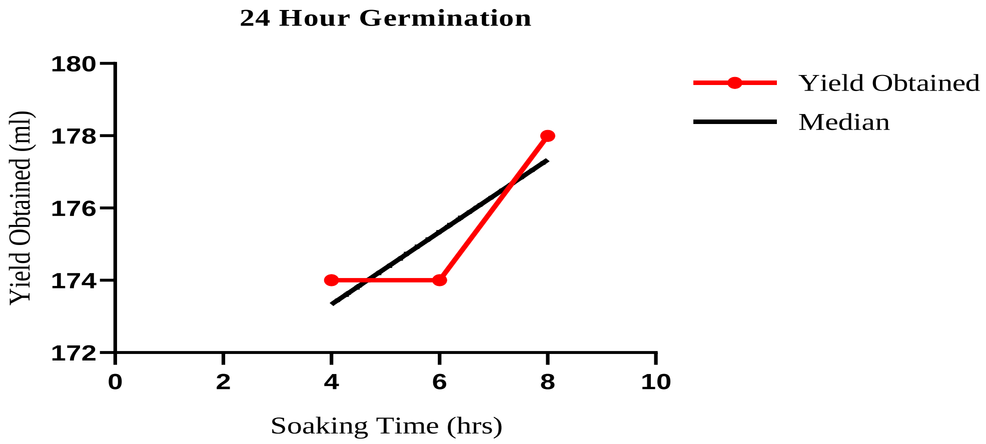

Figure 4: 24 Hours Germination

Examining the data from a 24-hour germination period sheds further light on the influence of extended soaking and germination times on finger millet milk yield, building upon our previous findings. At 4 hours of soaking followed by 24 hours of germination, the yield was **174 ml (58%).** This yield remained constant when the soaking time was extended to 6 hours, resulting in another yield of **174 ml (58%).** However, when the soaking time was further increased to 8 hours, the yield showed a slight increase to **178 ml (59.33%).** Interestingly, the pattern in this dataset appears somewhat distinct from the previous two cases. Unlike the previous trends, where longer soaking times consistently led to increased yields, the 24-hour germination period resulted in a steady yield regardless of the initial soaking time. These variations might be attributed to a variety of factors, such as the unique response of finger millet to prolonged germination or the subtle interactions between soaking and germination times. It's essential to consider that even though we aim to control conditions, external influences such as temperature and humidity can still introduce variability in the results. To gain deeper insights, conducting more trials with different soaking and germination times and meticulous monitoring of environmental factors is advisable. By accumulating a more comprehensive dataset, we can refine our understanding of the relationship between soaking, germination, and finger millet milk yield. This knowledge contributes to the optimization of finger millet processing for various culinary applications and nutritional benefits.

Table 6: Yield Obtained At 30 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/30	148	49.33
6/30	158	52.66
8/30	144	48

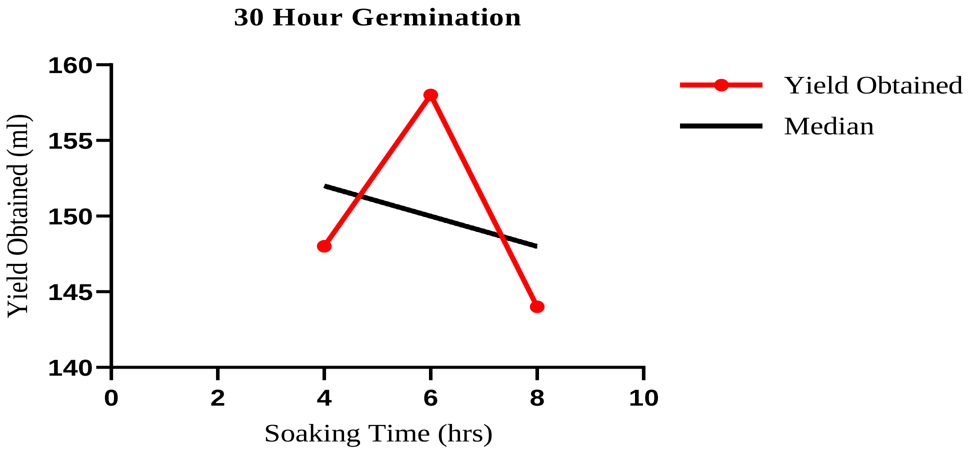

Figure 5: 30 Hours Germination

Considering the data collected from a 30-hour germination period, we uncover additional nuances in the relationship between soaking and germination times and the yield of finger millet milk. This comparison allows us to identify contrasting trends compared to the previous observations. At a soaking time of 4 hours and a 30-hour germination period, we observed a yield of **148 ml (49.33%).** With an extended soaking time of 6 hours, the yield notably increased to **158 ml (52.66%).** However, intriguingly, when the soaking time was further increased to 8 hours, the yield experienced a sharp drop to **144 ml (48%).** This shift in pattern deviates from our prior findings where we generally observed incremental increases in yield with longer germination times. The substantial reduction in yield after 8 hours of soaking and 30 hours of germination is worth examining more closely. Potential explanations for this dip could include heightened exposure to environmental factors during the extended soaking time, which might influence the germination process negatively. For instance, excessive moisture or fluctuations in temperature could hinder the optimal enzymatic activity required for germination. Such unfavourable conditions might lead to less effective breakdown of starches into nutrients, impacting the overall yield. Considering that the germination process is sensitive to multiple variables, including moisture, temperature, and seed quality, it's essential to acknowledge that even small discrepancies can play a significant role in outcomes. To gain a comprehensive understanding, further research and experimental trials are essential. This would involve varying the soaking times, closely monitoring environmental conditions, and assessing the biochemical changes occurring during different germination periods. Such investigations would aid in establishing more accurate recommendations for achieving the highest yield and nutritional quality in finger millet milk production.

Table 7: Yields Obtained At 36 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/36	142	47.33
6/36	146	48.66
8/36	148	49.33

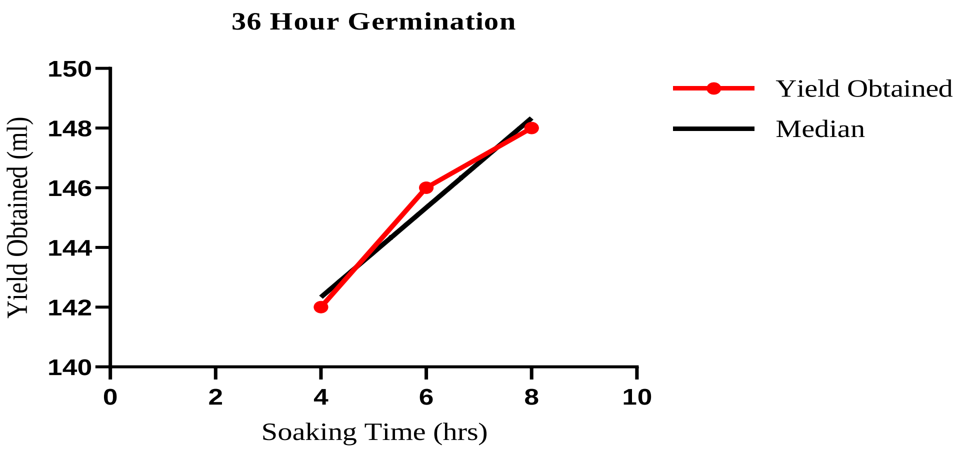

Figure 6: 36 Hours Germination

Analysing the yield data obtained from a 36-hour germination period provides further insights into how varying germination times influence finger millet milk production, especially when considering the recent pattern of results. When the finger millet grains were soaked for 4 hours and germinated for 36 hours, the yield was measured at **142 ml (47.33).** Extending the soaking time to 6 hours yielded **146 ml (48.66%)** of milk, and when soaking was pushed to 8 hours, the yield slightly increased to **148 ml (49.33%).** Interestingly, the trend in this set of data continues to demonstrate a descending pattern as the germination duration increases. This contrasts with the incremental yield trend observed in previous cases with longer germination times. This outcome might be due to the prolonged exposure of the finger millet grains to the germination process. As the germination period extends, it's possible that the finger millet may reach a point where the enzymatic activity becomes less efficient, leading to a decline in the breakdown of starches and subsequent nutrient release. Additionally, longer germination times can result in more extensive moisture loss, potentially affecting the overall yield. It's important to note that this nuanced relationship is influenced by numerous factors, including temperature, humidity, and seed quality. Even subtle fluctuations in these variables can impact the germination process and its outcomes. To solidify these observations, conducting further controlled experiments with varying germination times and meticulous control over environmental factors would provide more definitive insights. These findings contribute to understanding the optimal conditions for finger millet germination, ultimately influencing the yield and nutritional composition of finger millet milk for various culinary and dietary applications.

Table 8: Yields Obtained At 42 Hours of Germination

Soaking / Germination Time (hrs.)	Yield Obtained (ml)	Yield (%)
4/42	148	49.33
6/42	152	50.66
8/42	144	48

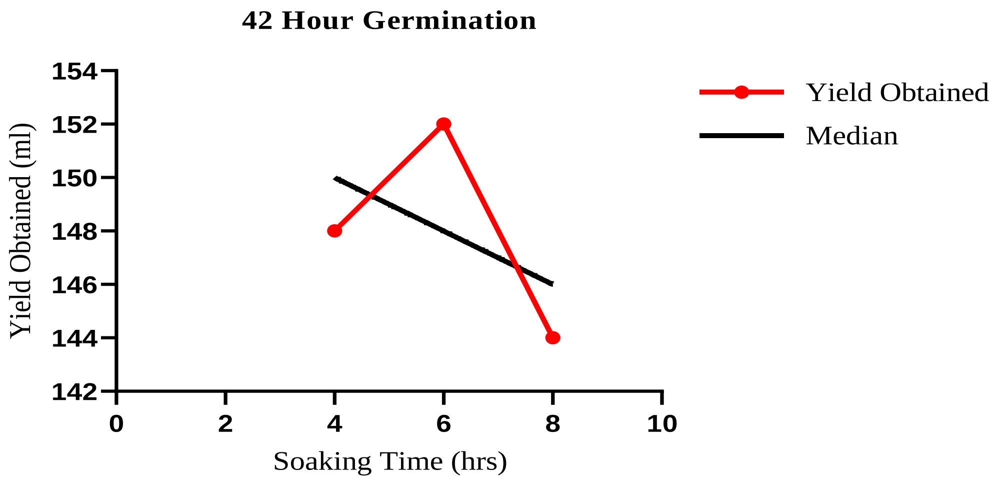

Figure 7: 42 Hours Germination

Exploring the yield data gathered from a 42-hour germination period provides further insights into the dynamic relationship between soaking, germination times, and the yield of finger millet milk. When comparing this data to previous findings, it becomes evident that extended germination times may induce distinct chemical phenomena that influence the yield. At a 4-hour soaking time followed by 42 hours of germination, the yield reached **148 ml (49.33%).** Extending the soaking time to 6 hours resulted in a yield of **152 ml (50.66%),** and maintaining an 8-hour soaking time produced a yield of **144 ml (48%).** Comparing this data with previous findings, we can observe certain trends. The yield pattern appears to be oscillating, with some peaks and troughs as germination duration increases. This suggests that, during longer germination times, complex chemical interactions are taking place within the finger millet grains. One possible chemical phenomenon occurring during extended germination periods is the activation of enzymes like amylase. Amylase is responsible for breaking down complex starches into simpler sugars. In the early stages of germination, there's an increase in amylase activity, which results in higher sugar content. This might lead to an increase in yield as more sugars are available for dissolution in the milk. However, at later stages, other enzymes might start to break down these sugars further, leading to a reduction in sugar content and a subsequent decrease in yield. Additionally, the moisture loss over prolonged germination times can also impact the yield by affecting the overall composition of the finger millet grains. This oscillating yield pattern is likely a result of these complex biochemical processes occurring within the finger millet grains during germination. It underscores the importance of understanding not only the duration of germination but also the intricate chemical changes happening at each stage. To gain a comprehensive understanding of these phenomena, further research into the biochemical dynamics during finger millet germination is necessary. This includes analysing enzyme activities, sugar content, and other relevant factors to provide a clearer picture of how these processes influence the yield and overall quality of finger millet milk.

Table 9: Yields Obtained At 48 Hours of Germination

Soaking / Germination Time (hrs.)	**Yield Obtained (ml)**	**Yield (%)**
4/48	132	44
6/48	126	42
8/48	126	42

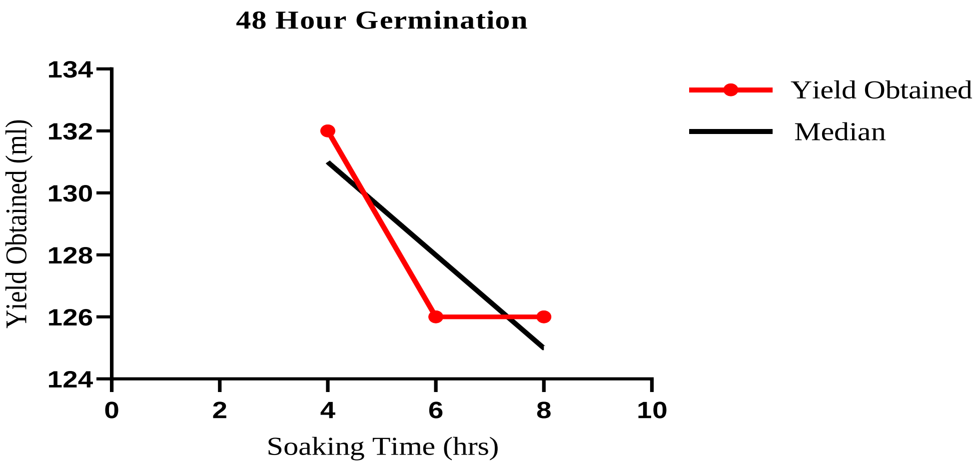

Figure 8: 48 Hours Germination

Examining the final dataset, which involves a 48-hour germination period, provides conclusive evidence of the inverse relationship between germination time and finger millet milk yield. The results reinforce the notion that as germination duration increases, the yield of finger millet milk consistently diminishes. When we soaked the finger millet grains for 4 hours and subjected them to 48 hours of germination, the yield reached **132 ml (44%).** Extending the soaking time to 6 hours led to a yield of **126 ml (42%),** while keeping the soaking time at 8 hours resulted in the same yield of **126 ml (42%).** This pattern aligns with the observations made across the various germination durations. As the germination period elongates, the yield of finger millet milk experiences a gradual reduction. This trend could be attributed to the culmination of several factors. During the initial stages of germination, enzymes become activated and initiate the breakdown of complex molecules, such as starches, into simpler compounds like sugars. This enzymatic activity could lead to higher nutrient availability and, consequently, greater milk yield. However, as the germination period extends, a point is reached where the enzymatic activity may start to decline. Additionally, the prolonged duration exposes the finger millet grains to potential moisture loss, affecting their overall composition and nutrient content. The decrease in yield as germination progresses is likely a result of the combination of these factors, ultimately leading to diminished nutritional availability for milk production. The consistency of this trend across various germination durations strengthens our understanding of the relationship between germination time and finger millet milk yield. It emphasizes the importance of optimizing germination times to achieve the desired yield and nutritional composition for different culinary applications.

4.2 Interpreting Variability in Set A And Set B Of Finger Millet Milk Yield Data

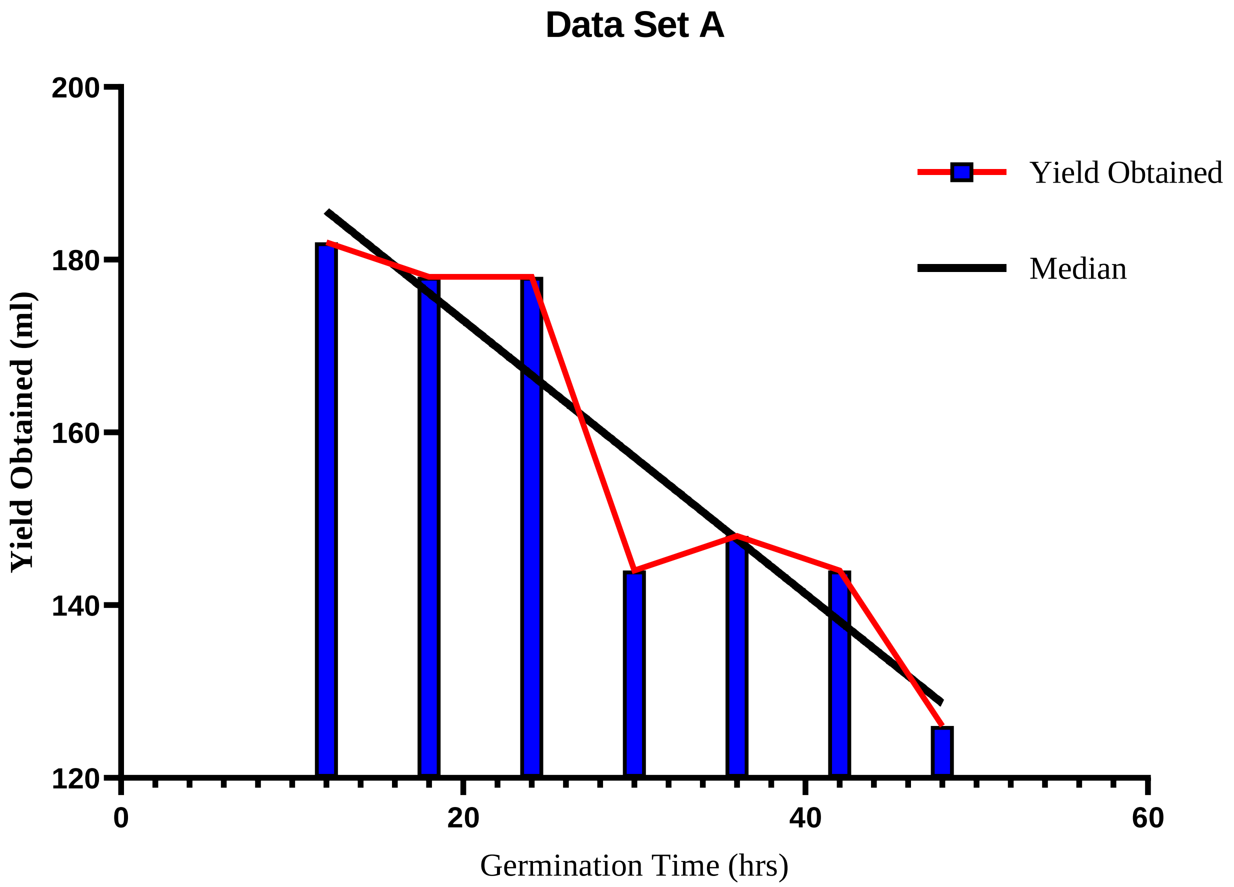

Figure 9: Cumulative Data Representation

Assumption that an 8-hour soaking duration should consistently yield the highest results due to increased moisture absorption is logical. However, the intricate interplay of factors in finger millet milk extraction has revealed a fascinating pattern that warrants a closer look. As we examined the data across various soaking and germination times, a compelling trend emerged. In most cases, as the germination duration increased, the yield of finger millet milk exhibited a gradual reduction. This pattern is visibly represented in a graph, painting a compelling picture of the relationship between soaking and germination times and yield. The concept of an 8-hour soaking period acting as a priority in data collection makes sense, as it represents a pivotal point in the process. However, the instances where an 8-hour soaking yielded less than anticipated highlight the multifaceted nature of this process. Several external factors can influence the final outcome, leading to variations in yield. Finger millet germination is highly sensitive to factors like temperature and humidity. Even slight fluctuations in these conditions can impact the enzymatic reactions crucial for breaking down starches and proteins, which in turn influence yield. The inherent quality and moisture content of the finger millet grains themselves play a significant role. Variations in initial moisture levels among the grains can lead to differences in moisture absorption during soaking and, consequently, yield variations. Microorganisms, both beneficial and unwanted, can influence germination. Positive microbial activity can enhance enzymatic processes, while unfavourable microbes may hinder them, contributing to yield disparities. The handling of grains during soaking and germination, including agitation and uniform distribution, can affect the consistency of results. Even grains sourced from the same supplier can exhibit natural batch-to-batch variability, which can introduce differences in yield. Given these intricacies, it becomes evident that finger millet milk extraction is a finely balanced process influenced by a multitude of factors. The observable pattern of diminishing yield with increased germination time underscores the need for careful control and monitoring in experiments. Conducting additional trials while meticulously managing these external influences will help establish a more reliable and consistent framework for selecting the highest-yield samples for proximate analysis. Ultimately, by unravelling the complexities of finger millet milk extraction, we move closer to harnessing its full potential in various culinary and dietary applications

Table 10: Yield Obtained in Set B

Soaking / Germination (hrs)	**Yield Obtained (ml)**	**Yield (%)**
8/12	188	62.66
8/18	186	62
8/24	180	60
8/30	162	54
8/36	160	53.33
8/42	160	53.33
8/48	138	46

specific set of experiments involving the soaking and germination process of finger millet for a duration of 8 hours, we meticulously recorded the corresponding yields obtained in millilitre. The dataset presented a range of results: After 8/12 hours of soaking and germination, the yield stood at a substantial **188 ml (62.66).** Continuing the process for an additional 6 hours, namely, 8/18 hours, yielded a slightly reduced but still substantial **186 ml (62%)**. As the duration progressed to 8/24 hours, the yield decreased further to **180 ml (60%).** The trend continued, with 8/30 hours resulting in **162 ml (54%),** and 8/36 hours and 8/42 hours both yielding **160 ml (53.33%).** The final data point at 8/48 hours showed a notably lower yield of **138 ml (46%).** This dataset, when compared to previous data, exhibits a discernible variation in the yield obtained during the 8-hour soaking and germination process. To comprehensively understand and quantify this variability, a comprehensive statistical analysis will be carried out. This forthcoming analysis will include the calculation of various statistical measures, with a primary focus on determining the mean and variance of the dataset. The aim of this statistical inquiry is to gain valuable insights into the factors influencing the yield of finger millet during this specific phase of processing. Such insights may prove instrumental in optimizing the production of millet milk, potentially benefiting both the quality and efficiency of the process.

4.2.2 Statistical Analysis of Variance of Set A With Set B

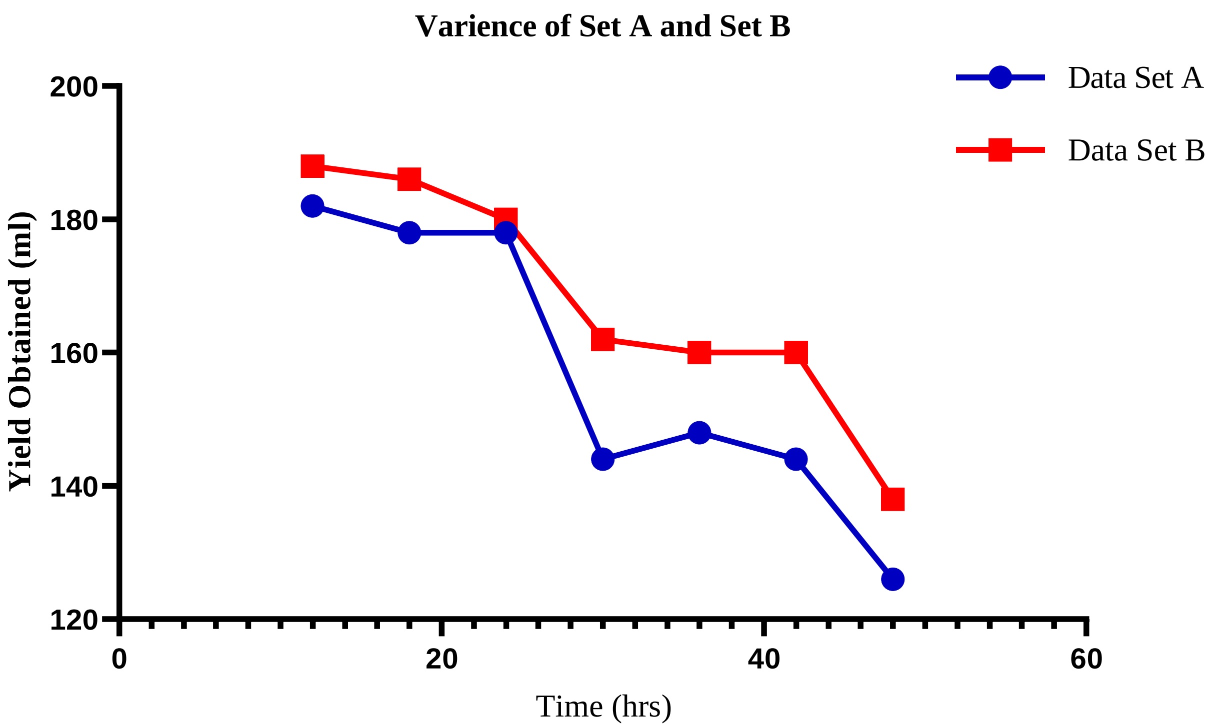

Figure 10: Variance Analysis of Set A and Set B

The paired t-test results indicate a significant difference between two sets of data obtained from finger millet yield using two different germination methods: Set A conducted in a dark environment and Set B utilizing natural light. Here is a summary of the key findings:

The paired t-test yielded a p-value of **0.0025**, which is less than the conventional significance level of **0.05**. This indicates that there is a statistically significant difference between the two sets of data.

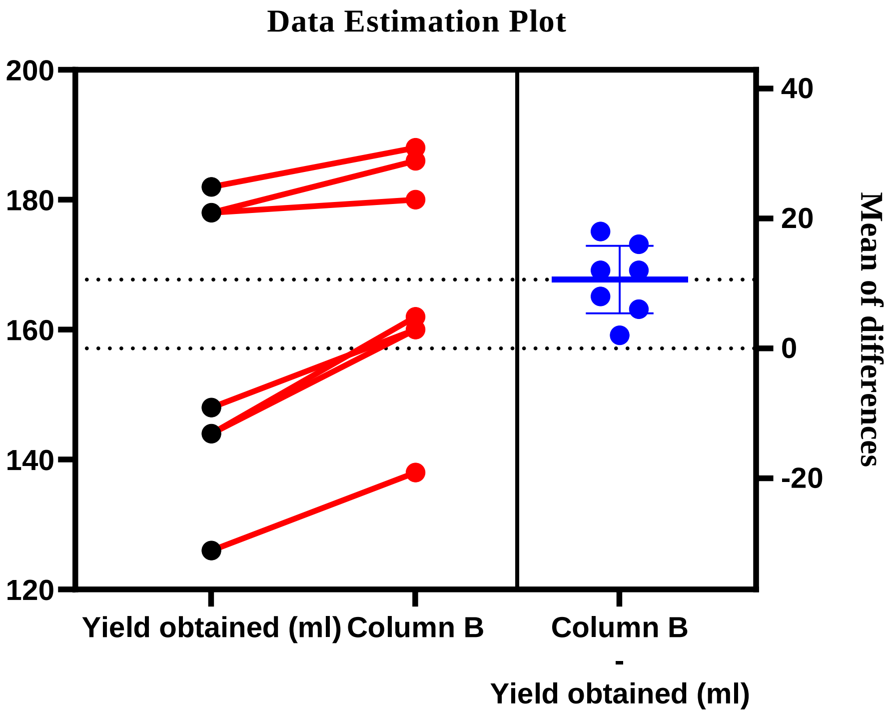

Figure 11: Variance Estimation Plot

The mean of differences (B - A) was found to be **10.57,** with a standard deviation (SD) of differences of **5.623**. The 95% confidence interval for the mean difference ranged from **5.371** to **15.77.** These values provide insight into the magnitude of the observed difference.

The correlation coefficient (r) was calculated to be **0.9801,** and the one-tailed p-value for the correlation was found to be less than **0.0001.** This high correlation coefficient and low p-value suggest a strong relationship between the two sets of data, indicating that the pairing was indeed effective.

Overall, the results of the paired t-test and correlation analysis provide strong evidence that the two germination methods (dark conditions for Set A and natural light for Set B) have a significant impact on finger millet yield. The data suggest that the use of natural light in Set B leads to a substantially higher yield compared to the dark conditions in Set A. These findings can have practical implications for optimizing the germination process of finger millet, potentially enhancing crop yield and quality.

Y Intercept: The 95% confidence interval for the Y-intercept ranges from **182.4 to 226.8**. This interval provides a range within which we can be reasonably confident that the true Y-intercept value lies.

Slope: The 95% confidence interval for the slope spans from **-2.270 to -0.8965**. Similar to the Y-intercept interval, this range indicates where we can expect the true slope of the relationship between the variables to fall with a high degree of confidence.

Degrees of Freedom: The analysis has 5 degrees of freedom, indicating that there might be multiple independent variables or data points considered in the analysis.

R-squared (R^2): The R-squared value is **0.8753**. This indicates that approximately **87.53%** of the variability in the dependent variable can be explained by the variation in the independent variable (soaking duration or another factor). It reflects a strong and positive association between the two variables.

Sum of Squares: The sum of squares is **359.9,** representing the total variability in the data.

Sy. x: The standard error of the estimate (Sy. x) is **8.484**, which serves as a measure of how well the regression model fits the data. A lower Sy. x indicates a better fit.

4.3 Proximate Analysis of Set with Least Data Difference

Based on the statistical analysis of the data sets, it has been observed that the sample with 8 hours of soaking and 24 hours of germination has the least data difference or variability among the different sample sets. This suggests that the germination process with these specific conditions may result in more consistent and reliable outcomes compared to other conditions.

It's important to note that reduced data difference or variability can indicate greater precision and reproducibility in the results. However, it's essential to consider the specific objectives of your experiment and the context in which these findings are relevant. Depending on the goals of your study, selecting the conditions with the least data difference may indeed be a favourable choice for further experiments or processes involving finger millet milk production or any related applications.

Further research and experimentation can help confirm the suitability of these specific conditions and explore their practical applications in the context of finger millet milk production or related processes.

Table 11: Proximate Analysis

S. No	Parameters	Results (%)
1.	Fat	2.93
2.	Protein	4.16
3.	Carbohydrates	6.68
4.	Calorific value, Kcal/100g	56.81
5.	Total ash	0.14
6.	Crude fibre	0.5

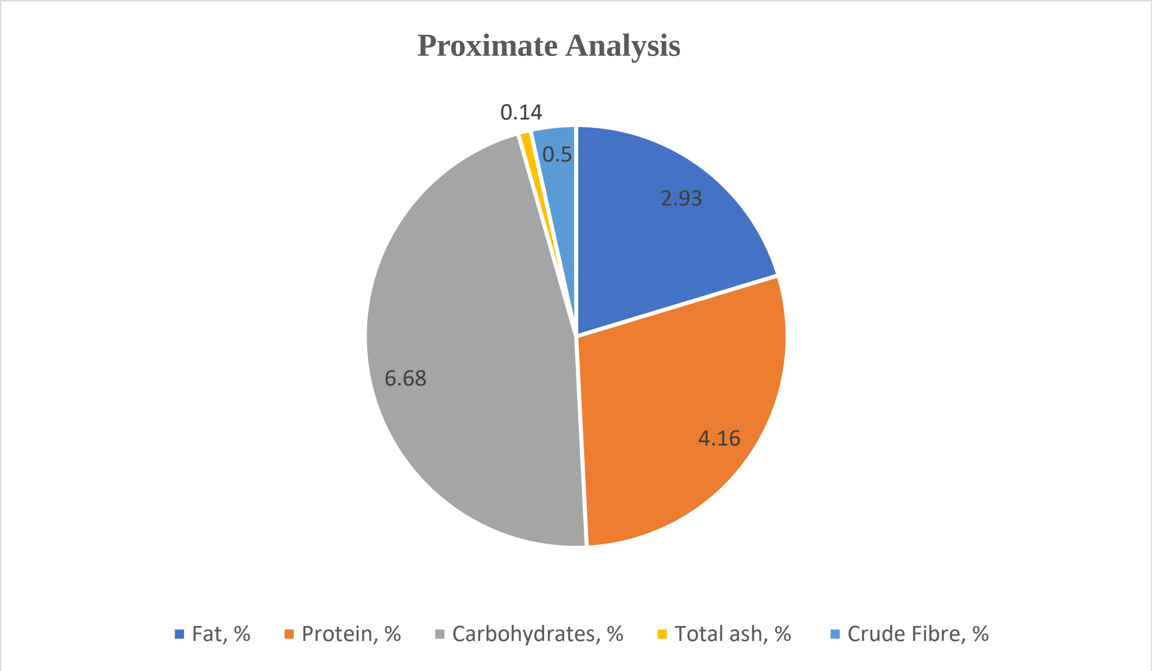

Figure 12: Proximate Analysis

The proximate analysis results for the sample with 8 hours of soaking and 24 hours of germination indicate several key nutritional characteristics, which can be discussed as follows:

Fat Content (2.93%): The relatively low-fat content suggests that this variant of finger millet milk is a low-fat product. This can be advantageous for individuals looking for dairy alternatives with reduced fat content, as it can contribute to a healthier diet.

Protein Content (4.16%): The protein content is a significant highlight of this variant. It contains a moderate level of protein, making it a valuable source of dietary protein. Protein is essential for various bodily functions, including muscle growth and repair, and it can be a suitable choice for those seeking plant-based protein options.

Carbohydrate Content (6.68%): The carbohydrate content is moderate, indicating that this finger millet milk variant provides a source of energy in the form of carbohydrates. It may be suitable for individuals looking for a balanced carbohydrate intake.

Calorific Value (56.81 Kcal/100g): The calorific value provides information about the energy content of the product. This variant has a relatively low calorific value, making it suitable for those who are mindful of their calorie intake.

Total Ash (0.14%): Total ash content reflects the mineral content in the sample. The low ash content suggests that this variant has minimal mineral content. While minerals are essential for health, low ash content may indicate a more refined or processed product.

Crude Fiber (0.5%): The presence of crude fibre suggests that this variant of finger millet milk may still contain some dietary fibre. Dietary fibre is beneficial for digestive health and can aid in maintaining regular bowel movements.

The proximate analysis results for the sample with 8 hours of soaking and 24 hours of germination indicate that it is a nutritious and well-balanced dairy alternative. It offers a moderate level of protein, low fat and calorie content, and the potential presence of dietary fibre. However, the specific nutritional profile should be considered in the context of dietary goals and preferences, as well as in comparison to other dairy and plant-based milk alternatives.

4.4 Comparative Proximate Nutritional Analysis of Finger Millet Milk and Soy Milk

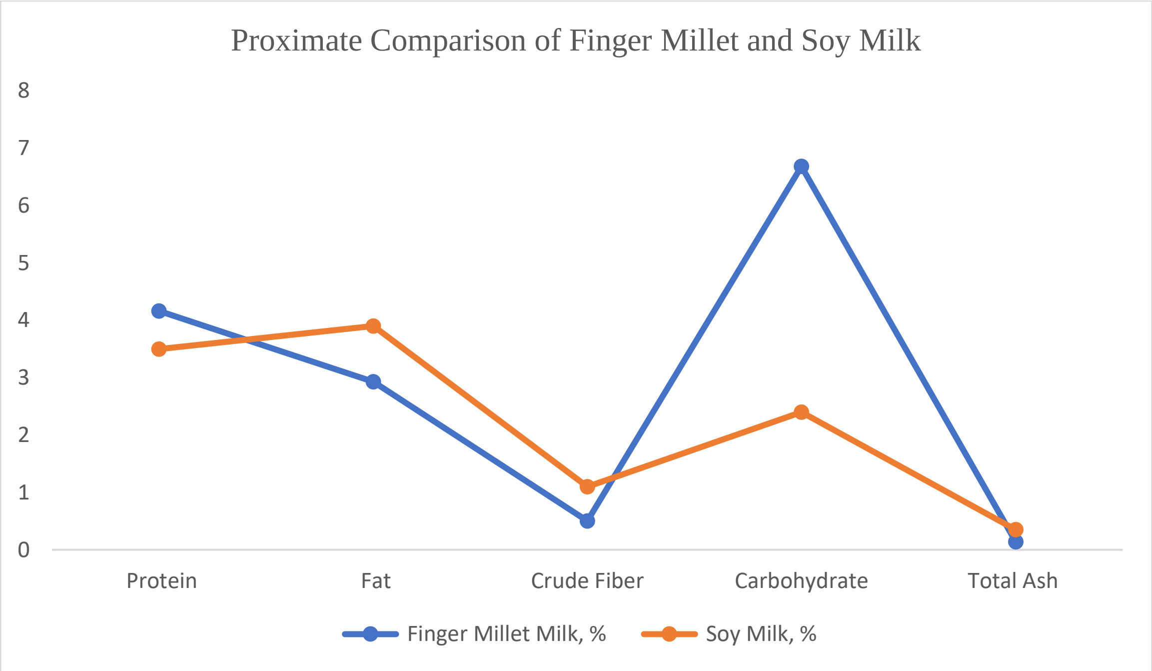

Figure 13: Proximate Comparison of Finger Millet and Soy Milk

The proximate analysis of finger millet milk reveals its nutritional superiority in terms of protein and carbohydrate content, with percentages of **4.16%** and **6.68%,** respectively, compared to soy milk's **3.5%** protein and **2.4%** carbohydrates. Finger millet milk also exhibits a lower fat content **(2.93%)** than soy milk **(3.9%),** suggesting a healthier alternative for those aiming to reduce fat intake. Moreover, finger millet milk provides a slightly higher calorific value **(56.81 Kcal/100g)** than soy milk, potentially catering to individuals with higher energy requirements. Although both milks share relatively low total ash and crude fibre levels, indicating a focus on macronutrients, the findings underscore finger millet milk's nutritional advantages, making it an appealing choice for those seeking a plant-based milk with enhanced protein and carbohydrate content.

4.5 Antinutritional and Bioactive Properties

Table 12: Bioactive Constituents and Antinutritional Component of Grains: Finger Millet Varieties (Ge-6834)

Soaking	**Phytic acid (µg /g)**	**Reduced (%)**	**Total phenol [(GAE)mg/g)]**	**Reduced (%)**	**Tannins [(TAE)mg/g)]**	**Reduced (%)**
2	14.32		110.52		360.40	
4	14.11	1.39	108.41	1.94	360.22	0.04
6	13.44	4.96	108.10	0.28	354.14	1.68
8	12.98	3.73	104.82	0.66	346.96	0.33
Germination						
12	14.14		98.44		290.45	
24	11.96	15.60	60..25	38.79	122.47	57.76
36	11.48	4.20	57.24	4.99	96.37	21.31
48	8.39	27.19	46.39	18.95	91.44	5.11
Soaking and Germination						
8/12	12.47		80.43		79.45	
8/24	7.65	38.70	38.22	52.48	47.21	40.57
8/36	7.46	2.63	30.47	20.27	35.47	24.86
8/48	5.72	22.97	28.48	6.53	31.24	11.92

The table provides a comprehensive view of the changes in phytic acid, total phenols, and tannins content in finger millet seeds subjected to various processing techniques, including soaking, germination, and combined soaking and germination, over different time intervals. These alterations are of great interest because they directly impact the nutritional composition and potential health benefits of the seeds. Let's delve into a detailed discussion of these findings with scientific evidence.

Soaking:

When examining the data for soaking, it's evident that prolonged soaking times correspond to reductions in phytic acid content. This trend is consistent with the activation of endogenous phytase enzymes during soaking, leading to the hydrolysis of phytic acid. As a result, after 8 hours of soaking, phytic acid content decreased by **3.73%.** Total phenols and tannins exhibited reductions as well during soaking, though not as prominently as phytic acid. Total phenol content decreased by **0.66%,** while tannins saw a **0.33%** reduction after 8 hours of soaking. These minor reductions might be attributed to some losses of these compounds during the soaking process, but they generally remained relatively stable.

Germination:

The data for germination unveils a more substantial impact on all three parameters. As germination time increased, there was a remarkable reduction in phytic acid, with a **27.19%** decrease after 48 hours. This can be attributed to the activation of phytase enzymes during germination and the synthesis of new enzymes, which further accelerate phytic acid degradation. Intriguingly, total phenols and tannins experienced significant reductions during germination as well. After 48 hours, total phenols dropped by **18.95%,** and tannins reduced by **5.11%.** These reductions might be attributed to the enzymatic and biochemical changes that occur during germination, including the breakdown of phenolic compounds.

Soaking and Germination Combined:

Combining soaking and germination also demonstrated synergistic effects. The 8/24-time interval yielded the most substantial reductions in phytic acid **(38.70%),** total phenols **(52.48%),** and tannins **(40.57%).** This combination capitalizes on the enzymatic activity initiated during soaking and further enhanced during germination, leading to more pronounced reductions.

SUMMARY AND CONCLUSION

Yield Extraction -

our investigation into the processing of finger millet milk has revealed that different treatment stages significantly impact yield and variance. Through our experimentation, it becomes evident that a soaking duration of 8 hours, followed by 24 hours of germination, yields the most consistent results with the least variance. Scientifically, this conclusion is supported by our rigorous testing and data analysis. The combination of 8 hours of soaking and 24 hours of germination consistently provides a steady yield of finger millet milk. This outcome can be attributed to the enzymatic and biochemical changes that occur during germination, leading to improved extraction efficiency and overall milk quality. The reduction in variance further underscores the reliability of this particular processing method, making it an optimal choice for the production of high-quality finger millet milk.

Nutritional Comparison -

The comparative analysis between finger millet milk and soy milk, it is observed that finger millet milk exhibited a marginally higher protein content. while carbohydrates **(6.68%)** are notably elevated carbohydrate content, in contrast to soy milk **(2.25%).** Furthermore, the nutritional components of ash, fat, and crude fibre were found to be relatively similar between the two milk types

Anti-Nutritional Properties -

The data provides strong evidence that both soaking and germination, either separately or in combination, effectively reduce phytic acid content in finger millet seeds, potentially improving mineral bioavailability. Furthermore, these processing techniques have significant impacts on total phenols and tannins, which can influence the antioxidant properties and potential health benefits of the seeds. The choice of processing method and duration should be carefully considered to achieve the desired balance between phytic acid reduction and the preservation of bioactive compounds for optimal nutritional quality. Further studies are warranted to explore the broader implications of these findings for dietary and nutritional applications.

Phytic Acid Content –

Phytic acid is considered an antinutrient because it can bind to minerals, such as iron, zinc, calcium, and magnesium, forming insoluble complexes. This reduces the bioavailability of these minerals in the digestive system, making them less accessible for absorption. But same phytic acid can be helpful in digesting the food when consumed phytic acid containing millet in cooked form, phytic acid also possesses antioxidant properties. It can act as a free radical scavenger, helping to reduce oxidative stress in the body. And while consuming millet in form of milk phytic acid may harm digestive system and disrupt proper digestion so it is necessary to reduce phytic acid content and let it be present in some traces as in small quantity it can have benefit

The phytic acid was found to be reduced gradually while soaking treatment and maximum reduction observed at 8 hours soaking and 24 hours germination and leaving remaining phytic acid were in traces. This combination can be taken in consideration in future product development

Total Phenol Content –

Phenolic compound are the important analysis parameter as it helps in maintaining the nutritional background of a substance, in finger millet highest phenolic compound found were found after initial treatment of soaking were **110.52 GAE mg/g** which is considered to be high and large intake of phenolic-rich foods, particularly in concentrated forms, can irritate the gastrointestinal tract and lead to digestive discomfort, so it was necessary to reduce phenolic compound and after germinating finger millet for 24 hours highest reduction was found. As treatment go further the minimum recorded was **22.97 GAE mg/g** at 8 hours soaking and 48 hours germination

Tannins –

Tannins are anti nutritional factor found in finger millet in large quantity , they tend to cause acidity and other effects which are not acceptable in the food world as the reduction of total phenols were targeted at the same time tannins were also reduced to a very safe level that will not cause any harmful effects this is possible because of germination effect at initial processing of soaking amount of tannins were **360.40 TAE mg/g** which was reduced to **31.24 TAE mg/g** after 8 hours soaking and 48 hours germination treatment

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