DEVELOPMENT AND STANDARDIZATION OF MILLET-BASED NON- FERMENTED BEVERAGES

मिलेट-आधारित अ-किण्वित पेय पदार्थों का विकास एवं मानकीकरण

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THESIS

MASTER OF SCIENCE (COMMUNITY SCIENCE)

IN

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DEPARTMENT OF FOOD SCIENCE AND NUTRITION

COLLEGE OF COMMUNITY AND APPLIED SCIENCES, UDAIPUR

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR (RAJASTHAN)

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A

THESIS

SUBMITTED TO THE

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OF AGRICULTURE AND TECHNOLOGY, UDAIPUR

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR

THE DEGREE OF

MASTER OF SCIENCE (COMMUNITY SCIENCE)

(FOOD AND NUTRITION)

BY

MOKSHIKA SONI

2024

CERTIFICATE –I

CERTIFICATE OF ORIGINALITY

The research work embodied in this thesis, titled "**Development and standardization of millet-based non-fermented beverages**" submitted for the award degree of **Master of Science** at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), is an original and bonafide record of research work carried out by me under the supervision of **Dr. Nikita Wadhawan**, Department of DFT, CDFT, MPUAT, Udaipur. The contents of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or university for the award of any degree or diploma.

The work embodied in the thesis represents my idea in my own words, and where other ideas or words have been included, I have adequately cited and referenced the original sources. I also declared that I have adhered to all principles of academic honesty and integrity and have not misrepresented, fabricated, or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the university and can also evoke penal action from the source, which has thus not been properly cited or proper permission has not been taken when needed.

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This is to certify that this thesis entitled "**Development and standardization of millet-based non-fermented beverages**" submitted for the degree of **Master of Science** in Community Science in the subject of Food and Nutrition embodies bona fide research work carried out by **Ms. Mokshika Soni** under my guidance and supervision and that no part of this thesis has been submitted to any other degree. The assistance and help received during the course of the investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on / / 2024.

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This is to certify that Ms. Mokshika Soni student of **Department of Food Science and Nutrition, College of Community and Applied Science, Udaipur** has made all corrections/modifications in the thesis entitled "**Development and standardization of millet-based non-fermented beverages**" which were suggested by the external examiner and the advisory committee in the oral examination held on .... the final copies of the thesis duly bound and corrected were submitted on .... are enclosed here with for approval.

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Enclosed one original and two copies of bound thesis, forwarded to the Director Resident Instructions, Maharana Pratap University of Agriculture and Technology, Udaipur through the Dean, College of Community and Applied Science, Udaipur.

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CERTIFICATE –V

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This is to certify that **Ms. Mokshika Soni** (M.Sc. Scholar) has worked under me on "**Development and standardization of millet-based non-fermented beverages**".

1. I have monitored her research work.
2. Myself and the scholar were in contact with the committee members and the research work was reviewed regularly.
3. The advisory committee members have gone through M.Sc. thesis critically and made the corrections as per requirement.

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Place : **(Mokshika Soni)**

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LIST OF ABBREVIATIONS

Abbreviation	:	**Full name**
^0C	:	Degree Celsius
et al.	:	*et alibi* (and associates)
i.e.	:	That is
G	:	Gram
Mm	:	Millimeter
Cfu	:	Colony forming unit
Mg	:	Milligram
mL	:	Milliliter
pH	:	Puissance de hydrogen
N	:	Normality
Lit	:	Liter
%	:	Per cent
TSS	:	Total Soluble Solids
Fig.	:	figure
S.	:	Serial
No.	:	Number
S.E.	:	Standard Error
C.D.	:	Critical Difference
µg	:	Microgram
Kcal	:	Kilocalorie
RTS	:	Ready-To-Serve
RTD	:	Ready-To-Drink
CE	:	Crude Extract
GAE	:	Gallic acid equivalents
FAE	:	Ferulic acid equivalents

INTRODUCTION

Millets are a group of exceedingly diverse, tiny-seeded grasses that are widely cultivated as cereal grains for human consumption across the world. According to Chivenge *et al.* (2015), they grow particularly in arid and semi-arid regions of Africa and Asia, including India and China, at 64º C and 350–400 mm annual rainfall, promoting millet growth (Soni *et al.,* 2023) . Unlike other cereals, they show tremendous interest because of their high nutritional value and agro-industrial significance (Saleh *et al.*, 2013). Millets are the oldest, and most likely the first cereal grain known to humans for domestic usage. These are classified into seven kinds, including varying colours, sizes, and cultivation zones, and belong to the *Poaceae* family (FAO, 2020). In a study conducted by Dayakar *et al*. (2017), it was reviewed that millets are C4 plants and are known for their high photosynthetic efficiency and high dry matter production capacity. And they have heat and drought tolerance power, so they can quickly adapt to growing in saline, acidic, and aluminium-toxic soils (Yadav and Rai, 2013).

According to Niti Ayog (2023), millets are slowly coming back to the diet as a healthy superfood. The year of 2023 is commemorated as the International Year of Millets (IYM), which provides a unique opportunity to engage all stakeholders to promote the production, productivity, and consumption of millets. Gowri (2020) reviewed statistical data in his study and found that in India, millets experienced negative growth rates of 16.31 percent and 13.58 per cent per year from 1950 to 2005 but showed positive growth 3.23 percent after 2005. From 1961 to 2018, global millet cultivation declined by 25.71 percent but productivity increased by 36 percent with India being the largest producer and West Africa showing the highest production growth (Meena *et al.,* 2021). According to a World Bank estimate, around 815 million people worldwide are hungry or malnourished (https://www.worldbank.org). According to Al-Amin and Ahmed (2016); Khanal and Mishra (2017), the globe is currently contending with a myriad of global concerns, including population growth, climate change, rising food costs, water scarcity, environmental pollution, and other socioeconomic repercussions. These unfavourable conditions may impede local agricultural expansion and restrict grain yield, resulting in high food prices and potential food security concerns. With these key challenges, the developing nation’s people do not get enough food, which leads to sickness and fatalities globally (Vila-Real *et al.,* 2017). It was suggested by Kumar *et al.* (2018) that by paying special attention to nutritional quality, millet cultivation can provide a comprehensive answer to the current difficulties of hunger and malnutrition as they suit the nutritional demands of the growing population. Praveen and Tandon (2016) estimated that consuming millets can help accomplish the United Nations' objective to eradicate malnutrition by 2030.

Millets are valuable for maintaining a balanced diet. According to Adebiyi *et al*. (2016), they offer a range of health benefits and can be particularly beneficial for those with specific dietary requirements or health concerns. Incorporating millets into a diet can contribute to overall well-being. Millets are nutritious grains that are high in protein, essential fatty acids, dietary fibre, B vitamins, and minerals such as calcium, iron, zinc, potassium, and magnesium. They contribute to improve the conditions including reduced blood sugar levels (diabetes), controlled blood pressure, thyroid, cardiovascular, and celiac disorders. They contain a wide range of micronutrients, and due to this, they require a longer time to digest. Kanorwala *et al.* (2022) found that millets are gluten-free, alkaline-forming grains and also high in phytochemicals and micronutrients, which play dynamic roles in the body's immunological system. They provide nutraceutical benefits in the form of antioxidants that safeguard human health by preventing cancer, diabetes, and decreasing tumour instances, among other things.

The fatty acids that are most commonly found in millets are linoleic acid, palmitic acid and oleic acid. Annor *et al*. (2015) found that starch-lipid complexes influence its sensitivity to starch-degrading enzymes, leading to delayed digestion. Pearl millet is abundant in protein, whereas barnyard millet has a lot of iron and fibre. Ragi is an excellent source of iron and calcium. Foxtail Millet has a lot of minerals and vitamins; little millet is high in iron and fibre, and proso millet is strong in lecithin, which is good for the nervous system. It is also high in minerals (P, Ca, Zn, and Fe), vitamins (niacin, b-complex vitamins, and folic acid), and important amino acids (methionine and cysteine). Jowar is gluten-free, energy-boosting cereal with good fibre content, and it is highly recommended for preventing cardiovascular diseases and other metabolic disturbances like diabetes and hypertension. Akanbi *et al.* (2019) described that barley contains carbohydrates, dietary fibres, and trace quantities of vitamins and minerals. Millet contains phenolic acids, like hydroxybenzoic acid including vanillic acid, gentisic acid, syringic acid and protocatechuic acid; hydroxycinnamic acid including, sinapic acid, ferulic acid, p-coumaric acid, and cinnamic acid, and some flavonoids including, quercetin, apigenin, catechin, and taxifolin. Singh and Sarita (2016) studied that bioactive compounds such as antioxidants and antimicrobial activity present in millets can generate numerous possible health advantages, and Nazari *et al.* (2018) define polyphenols as a kind of phytochemical that offer several health benefits, including reducing oxidative stress, preventing cancer, diabetes, and cardiovascular disease, and controlling hypertension.

Millets are hard seed coat grains, and due to their hard seed coat, their processing begins with husk removal (Jaybhaye *et al.*, 2014). They have more fibre and resistant starch. Their slowly digesting dietary components create a more durable sense of satisfaction and aid in the prevention of constipation by speeding food transportation through the gastrointestinal system, as reported by Rawat *et al.* (2020). They also discovered that they bind to and remove toxins from the stomach, therefore protecting the colon mucosa against cancer. According to Becker *et al.* (2014), celiac disease is an immune-mediated enteropathy caused by eating gluten-rich foods. However, Annor *et al.* (2015) suggested that millets are gluten-free seeds and are suitable for those who suffer from celiac disease or gluten sensitivity. As a source for this, Jnawali *et al.* (2016) introduce pearl millet benefits to cure celiac disease, constipation, and other non-communicable disorders. Foxtail millet is a popular food in China due to its ease of digestion, non-allergenic qualities, and substantial health benefits. In the study conducted by Nduti *et al*. (2016), it was said that millet-based fermented products are beneficial as probiotics and can cure diarrhoea in young children. High levels of calcium and iron present in finger millet. In research by Kumar *et al*. (2016), it was shown that finger millet is the most calcium-rich millet, with up to 10 times more calcium than brown rice, wheat, or maize, three times more than milk, and 34 times more calcium compared to milled rice. Gowda *et al.* (2022) described that modern processing techniques for Indian millets can improve their nutritional properties, but excessive dehulling, polishing, and milling can reduce dietary fibre and micronutrients.

Some millet-based fermented and non-fermented, alcoholic and non-alcoholic beverages made worldwide include: *Tongba* is an indigenous drink of Nepal, Bhutan, Sikkim, and Darjeeling prepared from fermented millet and served hot with a bamboo straw. Borzois is a thick and sweet drink prepared from fermented pearl millet, wheat, and maize. It is popular in Turkey, Bulgaria, Albania, and other Balkan nations. *Burukutu* is a sour and alcoholic drink produced from fermenting sorghum millet and it is very popular in West Africa, Nigeria, Ghana, and other nations. *Bushera* is a non-alcoholic and healthy drink prepared from millet, sorghum, or maize flour that is popular in Uganda, Rwanda, and other East African nations (Adebiyi *et al*., 2016). Millet milk is a plant-based milk replacement derived from millet grains. It is frequently used as a dairy-free milk alternative for those who have lactose intolerant and freshly adopted vegan diet.

Fermentation is a process that boosts the nutritional content of the beverage while also preserving its microbiological safety, eliminating the need for further preservatives. Millet beverages are often made from whole millet grains (Nayak, 2023). Though millets have been used in a variety of goods, their main culinary applications are still limited to traditional customs, and they are still relatively underutilised. Vincent *et al.* (2022) looked at food products made from millets in their study. They found that milling, roasting, germination, and fermentation are traditional processing procedures that yield a variety of primary and secondary millet products, such as dehusked grain, semolina, whole grain flour, and puffed millet. Modern technologies like extrusion, baking, spray drying, and malting have expanded the range of millet-based products, contributing to the preparation of instant mixes, ready-to-cook and ready-to-eat foods, and also develop innovative products such as *millet milk, dahi analogue,* and *meal bars*. Millets are additionally used in traditional cuisines, including *bhat*, *kheer*, *mudde, roti/chapatti, idli,* and *dosa*. The combination of traditional knowledge and new processing technology is critical for re-popularising millets, increasing their use in regular meals, and contributing to better worldwide dietary trends.

Ready-To-Drink (RTD) and Ready-To-Serve (RTS) food items are intended to provide convenience to consumers looking for quick and simple meal options. Bottled water, flavoured water, soft drinks, juices, smoothies, iced teas, coffees, energy drinks, and pre-mixed alcoholic beverages are examples of Ready-To-Drink (RTD) items. The RTS food items, on the other hand, are meals and snacks that have already been cooked or prepared and require little or no additional preparation before eating. RTS goods include canned soups, frozen meals, pre-packaged salads, sandwiches, snack packs, microwaveable meals, and instant noodles. Both RTD and RTS solutions provide a wide range of alternatives that save time and effort, making them suitable for today's fast-paced lives.

A study by Keskin, B., and Gunes, E. (2021) revealed that traditional beverages have major cultural, social, and health implications in many communities. These drinks, which are typically founded on traditional practices, not only add to cultural heritage but may also provide health advantages due to their distinct compositions and preparation techniques. Traditional beverages are an important part of a cultural legacy, helping to provide food security and social and religious traditions. It was found that many traditional beverages are rich in antioxidants and other bioactive substances, which can help lower the risk of degenerative illnesses, enhance cholesterol levels, and promote intestinal health. Historical and ethnobotanical studies emphasise the use of traditional beverages like alcoholic and non-alcoholic beverages in treating digestive, respiratory, and skin ailments.

Millet-based beverages are gaining popularity due to the growing demand for nutritional and functional drinks among people who are health-conscious. As government is also promoting millets for their health benefits and environmental resilience, they are becoming popular in global markets. Millets are high in vital minerals, gluten-free, and readily digested, making them great for preparing nutritious beverages. Despite these benefits, there have been zero studies on non-fermented millet-based drinks. This gap emphasises the importance of developing and commercialising such beverages in order to provide people with different and easy millet-based drink alternatives that can improve their diet and overall health. The beverage caters to a broad demographic, including children, adolescents, adults, and the elderly, tapping into the rising demand for healthy and functional beverages. Expanding the range of millet-based beverages can also help the food industry's attempts to provide more sustainable and healthy alternatives to conventional energy drinks.

Hence, it was decided to develop non-fermented beverages by incorporating millets into some traditional summer drinks for nutrient enrichment. The classic traditional drinks included were *thandai* and *sattu*. *Thandai* is a traditional Indian cold beverage made with a blend of milk, nuts, seeds, spices, and sweeteners. *Sattu* is a flour made from roasted grains like barley or chickpeas, commonly used in Indian cuisine to prepare beverages. To enriching them with more nutrients, pearl millet, ragi, foxtail millet, barley, and sorghum millet in *panch millet Sattu* and for *millet Thandai,* ragi, and foxtail millet are mixed. Therefore, the current study was conducted with the following objectives:

1. To develop and standardize millet-based non-fermented beverages.
2. To analyse the physico-chemical analysis and nutritional composition of the developed millet-based non-fermented beverages.
3. To estimate the shelf life of developed beverages.

DELIMITATIONS:

1. The raw materials were sourced only from local markets in Udaipur, Rajasthan.
2. The research is limited to using specific millet grains (pearl millet, sorghum, finger millet, foxtail millet, and barley) with the focus on non-fermented beverage preparation.
3. The shelf life was assessed at ambient temperature for 60 days, and refrigeration or other storage conditions were not extensively tested.

REVIEW OF LITERATURE

The review of literature is one of the first and most crucial tasks in any research work. Its purpose is to create a theoretical and conceptual framework by identifying many contributions that are related, either directly or indirectly. As a result, this chapter focuses on the relevant literature for the ongoing experimental investigation and discusses the current position of millet-based non-fermented beverage preparations. The findings of previous research projects that have a direct or indirect influence on the current research investigation are addressed under the following subheadings.

2.1 OVERVIEW OF MILLETS

Millets are a kind of small-seeded perennial grass grown as grains in marginal fields in drought-prone locations. Millets are ancient food grains that were originally cultivated for human consumption and are currently grown in 131 nations. Millets are an indispensable food for 59 million people in Africa and Asia. According to Sarita *et al.* (2016), millets as the sole crop will address future nutritional needs, animal production, fuel, hunger, health, and climate change problems. Millets may thrive in non-irrigated zones with less rainfall regimes extending from 200-500 mm. Millets are often identified as cereals with good nutrients, because they are an enhanced source of nutrients. They offer excellent nutrition and health advantages. They have ability to lower the risk of heart disease and helps to balance weight gain. Millets' particular makeup, which contains dietary fibre, polyols, and tryptophan, promotes weight reduction. Millets include phosphorus and many B vitamins, including niacin, folacin, riboflavin, and thiamine, which are vital for the body to produce energy.

Poshadri *et al.* (2023**)** defined millets as nutri-cereals because they are a better choice than cereal grains such as rice and wheat. They contain more nutrients including, complex carbohydrates, proteins with high-quality of amino acids, good-quality invisible fat, dietary fibre, and much increased levels of micronutrients such as potassium, calcium, magnesium, manganese, iron, zinc; bioactive phytochemicals and B complex vitamins. Similarly, Eduru *et al.* (2021) revealed that millets are an ancient crop that thrives in drought-prone, high-temperature conditions without diminishing productivity. These cereals are high in essential amino acids, minerals, vitamins, organic compounds, and carbohydrates, making them more nutritious than other basic cereals.

According to Chaurasia *et al*. (2023), millets are climate-resilient, robust, and dry land crops, and they provide a significant addition to food and nutritional security. They are defined as being healthier than other grains and contain a great concentration of protein, minerals, and phytochemicals. Millets are belong to the *Poaceae* family, and they are classified into seven kinds according to their physical attributes, including varying colours, sizes, and cultivation zones (FAO, 2020). The International Year of Millets was selected to offer an exceptional chance to involve every stakeholder in promoting the production, productivity, and consumption of millets. To address this, Gowri (2020) reviewed statistical data and found that in India, millets experienced negative growth rates of 16.31 per cent and 13.58 percent per year from 1950 to 2005 but showed positive growth of 3.23 percent after 2005. In a study by Meena *et al*. (2021), it was also reviewed that, from 1961 to 2018, global millet cultivation declined by 25.71 percent, but productivity increased by 36 percent.

In the study, Venkateswarlu *et al*. (2023) found that micronutrient insufficiency is exhibited as 'hidden hunger' in many impoverished nations, and millets appear to offer a potential solution for this. Millets such as finger millet, sorghum, and pearl millet are consumed whole (with husk) are high in vitamins, minerals, and dietary fibre. Small millets such as little, foxtail, proso, kodo and barnyard millets are also nutritious when they get mildly polished after dehulling. Srilatha (2014) concluded that millets provide a healthy diet and a secure environment through offering balanced food, a safe environment, and health care.

Millets are highly beneficial in malnutrition recovery, especially for children, due to their rich nutrient content. They provide essential vitamins, minerals like iron and calcium, and plant-based protein, which support muscle growth, bone development, and combat childhood anemia. The complex carbohydrates in millets offer sustained energy, vital for improving children's stamina and overall growth. Being gluten-free and boosting immunity, millets play a crucial role in enhancing the health of malnourished children, helping them recover and thrive (Anitha *et al*., 2022)

Millets, cultivated in drought-prone locations, and serve as essential grains for millions in Asia and Africa, providing better nutrition than wheat and rice. Millets contains high amount of dietary fibre, vitamins and minerals which give substantial health advantages as well as assist in weight loss. Millets are climate resilient and thrive in low-rainfall areas, contributing to food security and combating hidden hunger. Promoting their cultivation benefits both global nutrition and environmental sustainability.

2.2 NUTRITIONAL PROFILE OF MILLETS AND THEIR HEALTH BENEFITS

Millet is an alkaline-forming food and gluten-free grain, and millet oil may contain high levels of linoleic acid and tocopherols. Sarita and Singh (2016) found that cereal-based meals have a low bioavailability of minerals such as iron and zinc, which causes serious problems for new-borns and young children. Millets are also high in phytochemicals, micronutrients, antioxidants, and nutraceutical characteristics that are good for the body's immunological system and aid in controlling blood pressure and minimising the risk of abstaining from cancer, heart disease, diabetes, and tumour incidence. Former health advantages include prolonging the duration of stomach emptying and providing roughage to the gastro intestine. Millets are valued for their nutritional benefits, including nutrients such as minerals, carbs, and dietary fibre, as well as possible medicinal advantages, and they have been more well-known in recent years as a result of their remarkable nutritional richness and potential health advantages. Furthermore, he also investigates the fact that millets are gluten-free in nature and cover dietary needs. Tripathi *et al*. (2023) noticed that millet intake can prevent and manage chronic illnesses such as diabetes and cardiovascular ailments through the existence of bioactive compounds such as antioxidants and polyphenols.

In a study by Eduru *et al.* (2021), millets have a high nutritional profile and provide various health benefits, including anti-carcinogenic, anti-mutagenic, antioxidant, and antibacterial properties that can aid in the prevention of a variety of serious ailments such as diabetes, cardiovascular disease, and cancer. Millets are non-acid generating, easy to digest, and allergy-free. In their research, Popović *et al*. (2020) studied the productivity and importance of millets. It was found that millets are to be considered a high-yielding crop with significant protein content. Due to their high biomass yield, they are considered to be ideal for bioenergy production. They are high in iron, calcium, and the vitamin B complex (B1, B2, and B3). In addition to their nutritional benefits, they have been demonstrated to decrease blood pressure, the threat of cardiovascular disorders, cholesterol, the incidence of tumours, and the rate at which fat is absorbed. They also appear to prevent cancer and cardiovascular disease.

Rotela *et al.* (2021) revealed that millets are claimed to be a key source of nutrients due to their antioxidant, anti-aging, antibacterial, and anti-carcinogenic characteristics, as well as several critical vitamins such as beta carotene (yellow pearl millets), niacin, riboflavin, thiamine, and minerals (Ca, Zn, Mg, Fe, and Cu). Millets have been shown to provide a number of medical advantages including protection against celiac disease, diabetes mellitus, cardiovascular disease, digestive system issues, malnutrition, and a number of other ailments.

Millets continue to be the primary food source for billions of poor people in Asia and Africa. They aren't officially recognised to be one of the best essential diets in United States and in European's diet, but they are vital for the component in gluten-free, multi-grain products.

Millets are rich in fats including saturated and unsaturated fatty acids, essential amino acids, and dietary fibre, which are crucial for the body's normal functioning. Millets contain minerals like iron and copper, which improve blood cell synthesis and oxygenation, and phosphorous, which lowers blood pressure and improves resistance to illnesses. Ambati *et al.* (2019) revealed that consuming millets can lower triglycerides, prevent coronary artery disease, and increase HDL levels. They are gluten-free grains, making them popular among vegans and vegetarians. Millets also contain tryptophan, fibre, and phytonutrients, which can help manage weight, reduce colon cancer risk, and reduce asthma and migraine frequency.

Sharma and Niranjan, (2018) investigated the physicochemical and health-functional features of foxtail millet, as well as the processing processes used to improve them. Foxtail millet is said to have a significant amount of protein, fibre, minerals, phytochemicals, hypolipidemic property, low-glycemic index, and antioxidant properties. It was found that in foctail millet, anti-nutrients are present such as tannin and phytic acid, but it can be reduced to minor amounts with appropriate processing techniques.

Foxtail millet seeds contain proline-rich setarins, which account for about 60 percent of the total protein. Efforts are being made to extract and use this protein in agriculture, food, and pharmaceuticals, and in other bio-based products. Sachdev *et al.* (2021) found that foxtail millet protein may show bioactive activity useful in the prevention of chronic diseases. Its low cost makes it an excellent alternative source compared to animal proteins, having good potential to develop a low-cost, protein-rich functional food to prevent and treat chronic diseases.

According to Chaurasia *et al.* (2023), millets are defined to be healthier than other grains and consist a great concentration of protein, minerals, and phytochemicals. In millets, approx. 5 percent fat, 7–12 percent protein, 15-20 percent dietary fibre and 65–75 percent carbohydrates, can be found. Millets have been shown to be extremely beneficial for patients suffering from diabetes, cancer, hypertension, cardiovascular diseases, celiac disease, osteoporosis, and other disorders.

Millets have been proven to be outstanding homes of crude fibre, crude fat, and iron that are ranged from 9.3 to 56.7 percent, 11.5 to 31.7 percent, and 2.1 to 8.0 percent mg/100g respectively. Oleic acid and Linoleic acid are the most abundant unsaturated fatty acids found in all millet species. Kodo millet has the greatest levels of free and bound phenolic. (Bora *et al*., 2019). Finger millet has high-calcium content (344mg/100g) that can help youngsters, pregnant women, and the elderly to maintain good bone health. As a result, Venkateswarlu *et al*. (2023) concluded that frequent consumption of millets can contributes to diet diversity and provides several health benefits.

Millets are abundant in phenolic compounds and have potent antioxidant properties. Phytochemicals present in millets can improve human health by lowering cholesterol levels. In an investigation by Hassan *et al.* (2021), the nutritional value of cereal grains vs. millets for animal feed was examined. The study examined how replacing maize with pearl millet and finger millet in animal diets can improve illness prevention. It was observed that the inclusion of at least 50 percent pearl millet in broiler meals showed no negative impact on functionality.

In the study of Xiang *et al*. (2019), free fractions of various levels of phenolics (ferulic acid equivalents), flavonoids (catechin equivalents), and tannins (catechin equivalents) were obtained, with values ranging from 114.43 to 179.19 mg FAE/100g, 90.24 to 202.94 mg CE/100g, and 31.76 to 83.59 mg CE/100g. The phenolic content present in bound segments were ranged from 58.27 to 123.23 mg FAE/100 g. It was observed that among the twenty phenolic compounds and eighteen flavonoids, catechin and epicatechin were the most frequent. The bound fractions included seventeen phenolic compounds, the most prevalent was ferulic acid. Darker-coloured finger millet variations revealed high amount of phenolic content and lighter-coloured varieties revealed their antioxidant activity. Ragi can be employed for both healthy meal and a natural antioxidant source.

The study was conducted by Kumari *et al*. (2017) on three different millet types cultivated in Sri Lanka's dry and intermediate climatic zones. In finger millet, foxtail millet, and proso millet, phenolic compounds were identified. Finger millet showed the highest phenolic content of 0.19 to 3.37 CE/g and great antioxidant activity compared with foxtail millet and proso millet. The variety and cultivation region of millets had an impact on the phenolic content and antioxidant activity of soluble and bound phenolic extracts.

Millets are gluten-free, alkaline-forming grains high in minerals, antioxidants, and bioactive molecules. They have several health advantages, including increased immunity, decreased hypertension, and a reduced risk of cardiovascular disorders, cancer, and diabetes. Millets are found to be easy to digest, free of allergens, and abundant in vital amino acids, fatty acids, and dietary fibre. Their strong nutritional profile and therapeutic characteristics make them ideal for controlling chronic conditions and maintaining general health. Furthermore, millets are excellent for bioenergy production due to their high biomass yield.

2.3 MILLET BASED BEVERAGES AND THEIR EFFECT OF PROCESSING-

Fasreen *et al.* (2017) developed a health-effective probiotic drink from finger millet (*Eleusine coracana*), sugar, fresh cow milk, and cocoa powder. It was found that the cooked finger millet was treated with *Lactobacillus casei* 431 and incubated for 2 to 6 hours at 37 °C. It was then kept in the refrigerator at 51 °C. The results concluded that the administration of probiotics reduced both reducing and non-reducing glucose.

A probiotic drink produced from finger and foxtail millet was considered a functional food. It was observed that it offers health advantages over millet malt. Mali *et al*. (2020) revealed that cooked malt was treated with *Lactobacillus acidophilus* and *Lactobacillus bulgaricus* bacteria and incubated at 37 °C for 4 to 6 hours, which dramatically reduced both reducing and non-reducing sugars.

An experiment was carried out by Bembem and Agrahar-Murugkar (2020) on millet-based beverages. Sorghum and finger millet with crushed coconut, cocoa powder and fresh carrot were used to enhance the sensory attributes of the beverage. A bench-top sensory evaluation method was used for optimisation. It was found that the prepared beverage contained total soluble solids ranged from 43.8 to 44.4 °Brix. It was observed that there was no subsequent change present in firmness, consistency, cohesiveness, or viscosity index across various treatments.

Navyashree *et al.* (2022) experimented on a white finger millet probiotic beverage, and they observed that an increase in white finger millet flour content and inoculum levels in the beverage had a big effect on the pH and microbial load. However, viscosity and TSS were also impacted by sugar levels.

A fermented millet-based beverage using an allergen-free starter (free of milk proteins, lactose, and gluten) was created. In the investigation of M. ziarno *et al.* (2019), for improving texture, the texture-improving food ingredients (pectin and corn starch mixes) were used. The product’s sensory evaluation, pH, and microbial test were done at 6 °C after 28 days of storage. The results of the product revealed that it was found to be good in taste as well as texture with regular yoghurt starter.

In a study, Chavan *et al.* (2018) developed a fermented beverage by cleaning, soaking, and germinating barley, finger millet, and moth bean seeds. After the germination process, the germinated seeds were dried, ground, and combined with sugar and cardamom. For dilution, mixtures of the beverage combinations were made, including distilled water, soy milk, almond milk, and coconut milk. As an inoculant, a probiotic bacteria called *Lactobacillus acidophilus* was added to the prepared drink. As a result, the probiotic drink made with coconut milk scored the uppermost sensory evaluation scores, Water, soymilk, and almond milk were the next most popular options.

The effect of roasting on germinated pearl millet (*Pennisetum glaucum*) for up to 5 days was examined by Kindiki *et al*. (2015). It was noticed the change in proximate composition, iron, zinc, calcium, and phytate levels. They also noticed that this procedure considerably reduced calcium and phytic acid levels and increased protein, ash, crude fibre, iron, and zinc levels. The germinated, fermented, and roasted flour produced a higher sensory quality than untreated millet flour.

Nazni *et al.* (2016) concluded in their study that the bulk density of barnyard and foxtail millet on boiling, pressure cooking, and roasting is substantially higher than that of the raw millet flours. And the bulk density of the germinated millet flours is lower. Similarly, the digestibility of millets has been defined by Singh *et al.* (2018) in their study. They claimed that the millet grain becomes more palatable by roasting and grinding. However, finger millet's functional and phytochemical composition—which includes moisture, fat, protein, phenols, and antioxidant activity—tends to somewhat diminish with roasting. The bioavailability of minerals like calcium and iron increases the overall carbohydrate content, ash content, and fibre content.

A beverage with multigrain functionality was developed using foxtail millet, barnyard millet, and kodo millet. The roasted millets were then extracted from the water. The beverage contained the amount of 10 g of foxtail, 7 g of barnyard, and 8 g of kodo millet, respectively. The study by Kumar *et al*. (2020) stated that the prepared beverage provided 5.72 g/100 g total dietary fibre, 47.69 mg FAE/100 mL total phenolic content, 1.56 prebiotic activity, and a 45.07 glycaemic index (GI < 55).

It was observed in a study by Kakade *et al*. (2015) that finger millet includes several anti-nutritional components such as phytin, saponin, trypsin inhibitor, and tannin; however, the tannin level of finger millet was found to be higher, and it was noticed that pre-treatments such as soaking, fermentation, decortications, germination, and extrusion cooking can reduce the amount of anti-nutritional components to acceptable levels. Phenolic components present in sorghum are mostly made up of phenolic acids, 3-deoxyanthocyanidins, and condensed tannins (Xiong *et al.*, 2019). Germination and fermentation improved the overall nutritional properties of millets, but excessive dehulling, polishing, and milling reduced dietary fibre and micronutrients (Gowda *et al.*, 2022).

Mishra *et al.* (2024) optimised extraction parameters for producing finger millet beverages, with an emphasis on yield, total solids, and sedimentation index. The best condition was the 10 hours of soaking at 60 °C, with a yield of 91.86 ± 0.94 percent. The beverage was additionally enhanced with the addition of xanthan gum and jaggery powder to increase its physicochemical and functional qualities. The resultant beverage had a high phenolic content, antioxidant activity, and a low ant-nutrient, tannin, and phytic content.

According to studies, probiotic and fermented millet beverages provide considerable health advantages, including decreased glucose levels and improved nutritional absorption. Treatments with Lactobacillus strains, as well as germination and roasting, increase the nutritional profile. The prepared beverages are high in dietary fibre, antioxidants, and important minerals. These characteristics make them ideal functional meals for digestive health and general well-being.

2.4 SHELF LIFE OF DEVELOPED MILLET BASED BEVERAGES

Geetha and Preethi (2020) produced a kodo millet-based advantageous milk beverage by extracting milk from sprouted kodo millet grains and water in a 1:7 ratio. The beverage was flavoured with 10 percent sugar and 0.1 percent cardamom, resulting in a TSS of 15º brix, acidity of 0.86, starch content of 5.73 percent, total sugar of 3.26 percent, reducing sugar of 1.79 percent and protein content of 1.75 percent per 100 g. The product had a three-month shelf life. Sprouting improved milk output, decreased viscosity, and reduced sedimentation. The beverage received great sensory ratings and had no detectable pesticide residue. The microbial load was 1.45 ± 0.17 colony-forming units ($\log 10^{-2}$), with a refrigerated shelf life of three months.

A study was conducted to make a composite drink by utilising oats, finger millet, and double-toned pasteurized milk. The drink was standardised and manufactured using a 60:40 ratio of finger millet malt to oats and three times the amount of water. The prepared beverage was flavoured with rose syrup and marigold powder. The composite drink was rich in total solids, carbs, minerals, and energy but low in fat, cholesterol, and lactose. It contains health-promoting nutrients such as soluble dietary fibre, beta-glucan, and anthocyanins. The drink was discovered to be an effective prebiotic and transporter for Lactobacillus bacteria. The composite and symbiotic beverages needed refrigerated storage and had a shelf life of 60 and 20 days at 4±2°C (Kumar *et al.,* 2017).

The goal of the study was to combine sorghum, horse gramme, and red rice (also known as "*kuruluthuda*") in a 5:2:3 ratio to produce a low-fat, low-calorie, gluten-free functional multigrain beverage. Kumar *et al*. (2017) developed millet-milk beverages with different grain extract ratios (60%, 65%, and 70%) of cow's milk, sesame milk, sweetener (Kithul treacle and sucrose), and carrageenan. The 70 percent multi-grain extract with sugar beverage was chosen based on sensory properties. The characteristics of pasteurised and sterilised beverages varied; however, polyunsaturated linoleic acid (35.41-38.56%) and oleic acid (34.01-34.16%) were the most prevalent fatty acids. Pasteurized sucrose and treacle-containing drinks had shelf lives of 14 days and 7 days, respectively. It was also revealed by Wickramaarachchi *et al*. (2024) that sterilised beverages have a shelf life of one year.

Rabadi, a traditional beverage made using fermentation process on pearl millet (*Pennisetum typhoideum L*.) flour with buttermilk, is popular in India's North-West region. A technique for producing Pearl millet based *Rabadi* with fermented whey was attempted. Fermented whey and PM flour were combined before fermentation. Poonia and Kumari, (2018) estimated the amount of flour, whey, and fermentation temperature using Response Surface Methodology (RSM) with Central Composite Rotatable Design (CCRD). After sensory assessment, the recipe made with 50 g of Pearl millet flour and 660 ml of fermented whey was incubated at 37.5°C to produced best results. The standardised product was kept in local pouches at 4°C and 10°C. The product's shelf life was 8 days at 4°C and 5 days at 10°C.

In the study of Kunle *et al*. (2017), researchers assessed the sensory qualities, nutritional content, and consumer acceptance of cereal grains used in *Kunu* production, such as maize, sorghum, and millet. The grains were sifted, soaked, milled, and sieved before being turned into *Kunu-zaki*. The sensory examination found that sorghum had a greater overall acceptance of 7.55 (about 76%) than any other cereal or millet, which had adequacy of 74 percent and 68 percent, respectively. Sorghum also had a lower titratable acidity score, which suggests a longer shelf life. It had a greater amount of fat, protein, and ash, with iron and copper as the main minerals. The study revealed that sorghum is the best grain for *Kunu* production because of its shelf life, nutritional value, and sensory qualities.

The physicochemical parameters of millet were investigated by Panigrahi *et al.* (2024), to assess their potential for fermentation. The probiotic culture included Lactic acid bacteria and *Bacillus clausii*, and fermented at 32 °C for 8 and 12 hours, respectively. The following parameters were measured throughout 14 days of storage at 6 °C: acidity, pH, Total Soluble Solids (TSS), protein, fat, ash, crude fibre, phytochemical content, and microbiological profile. Sensorial evaluation was also done at the conclusion of the storage period. It was observed that, when kept at 6°C for 14 days, the probiotic millet beverage maintained adequate sensory acceptability and shelf life. After 7 days of storage, viable probiotic cell counts were measured at 2.910 CFU/mL.

According to Noah *et al.* (2013), the production, microbial, physicochemical, and sensory quality of *Kunun-zaki* made from millet were assessed using an enhanced and conventional technique as controls, and the product was kept under two distinct circumstances (ambient and refrigerated). A total viable count of 0.1 x 104 - 1.5 x 10^4 cfu/ml and a yeast count of 0.2 x 10^4 - 0.8 x 10^4 cfu/ml were obtained from the microbial analysis of the developed product sample that was stored under both conditions. No growth of *Coliform*, *Staphylococcus*, and *Salmonella* was observed. The traditional process sample yielded a higher total viable count of 1.0 x 10^4 - 2.0 x 10^4 cfu/ml, 1.0 x 10^4 - 1.5 x 10^4 cfu/ml Coliform count, and 0.2 x 10^4 - 2.0 x 10^4 cfu/ml of yeast count. *Micrococcus acidophilus*, *Pseudomonas aerogenosa*, *Lactobacillus plantarium*, *Bacillus subtilis*, *Escherichia coli*, *Rhizopus nigrican*, *Penicillium sp.*, and *Saccharomyces cerevisiae* were the bacteria that were gathered. The two samples were found to have pH levels ranging from 3.0 to 4.6.

Ghoshal *et al.* (2024) developed a probiotic beverage using germinated and un-germinated pearl millet flour and green gramme milk. They mixed germinated and un-germinated pearl millet flour with green gramme milk in varied proportions (0.5-2.5%), as well as sugar and cardamom. The produced combinations were then injected with *Lactobacillus acidophilus*, a probiotic bacterium, and incubated at 37°C for 6 hours. Probiotic drinks were evaluated after 21 days of storage at 4 ± 1 °C. They noticed that the germinated flour beverage was more acidic than the non-germinated flour beverage. Probiotic counts in germinated and un-germinated flour beverages varied from 8.19 to 8.77 × 10^7 and 8.04 to 8.52 × 10^7 log CFU/mL, respectively. The antioxidant activity and polyphenol contents of the beverage rose as the flour concentration increased. The predominant polyphenolic components in the probiotic beverage were identified using LC-MS analysis as vitexin and isovitexin.

Recent research has highlighted the potential of millet-based drinks as functional and nutritional alternatives. Kodo millet milk beverages and composite beverages, including finger millet, oats, and milk, have boosted nutritional profiles consisting of high fibre, antioxidants, and essential nutrients. Process improvements, including sprouting and fermentation, enhance sensory quality, shelf life, and probiotic content. These drinks provide gut health advantages, making them important additions to the functional food industry.

METHODOLOGY

Procedural specificity and thorough observation of the study design are indispensable for any investigation. The present research was undertaken to develop and standardize millet-based non-fermented beverages and to evaluate the nutritional quality and shelf life of the developed millet-based beverages. The methodological details of the experiment conducted during the course of the investigation are depicted as below:

Locale of the study:

The study was carried out in the Department of Food Science and Nutrition, College of Community and Applied Sciences (CCAS), and the Department of Dairy and Food Technology, CDFT, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan.

3.1 Development and standardisation of millet beverages

3.1.1 Selection

3.1.2 Standardization

a) Planning of recipes
b) Procurement of raw materials
c) Preparation of recipe
d) Selection of panel
e) Sensory evaluation

3.2 Physico-chemical and nutritional analysis of the developed millet beverages

a) TSS
b) pH

3.2.1 Proximate composition

a) Moisture
b) Ash
c) Crude fat
d) Crude fibre
e) Crude protein
f) Carbohydrates
g) Energy

3.2.2 Mineral estimation

a) Iron
b) Calcium

3.3 Packaging of millet based beverages

3.4 Shelf life estimation of developed beverages

3.4.1 Microbial test

3.4.2 Sensory evaluation

3.5 Statistical analysis

3.1 Development And Standardization Of Millet-Based Beverages-

Unhealthy beverage consumption is a growing concern in India, with sugary drinks and processed juices contributing to health issues like obesity and diabetes. To address this, millets are incorporated in these drinks (*Thandai* and *Sattu*) beverages are introduced as healthier alternatives for people of all ages. This initiative seeks to promote better dietary choices and combat the negative health effects associated with excessive sugar intake in the Indian population.

3.1.1 Selection:

Millets are the oldest grains in the world, as they contain essential fatty acids, protein, dietary fibre, B-vitamin, and mineral content, including calcium, iron, zinc, potassium, and magnesium. To put that perspective in mind, millet beverages were taken as an opportunity to offer some healthy drinks to people of different age groups, like children, adolescents, adults, and older ones.

3.1.2 Standardization: the product was standardised in following stages:

a) **Planning of recipes:** The selected beverages namely *Panch Millet Sattu* and *Millet Thandai* utilise millets as a primary ingredient and were created and standardized to maintain a consistent weight and contain 40 per cent Total Soluble Solids (TSS).

Procedure for manufacturing *Panch Millet Sattu*:

1. High-quality millets were selected and processed.
2. After the cleaning process, millets and fennel seeds were roasted separately for 2–3 minutes to increase flavour and aroma.
3. Roasted millets were allowed to cool to ambient temperature before grinding.
4. Fine flour powder was created by grinding millets, which were then sieved through a 300-mm sieve.
5. The preparation of sugar syrup was done with a one-and-a-half-string consistency, and half a lemon was added to it to avoid scum formation and crystallisation.

6. The fine mixture was mixed into the sugar syrup when the syrup cooled.
7. And the drink was served using 2 tbsp. (20g) in 1 glass of chilled water.
8. The prepared drink was packed in a sterilised glass bottle and stored in a cool, dry place.

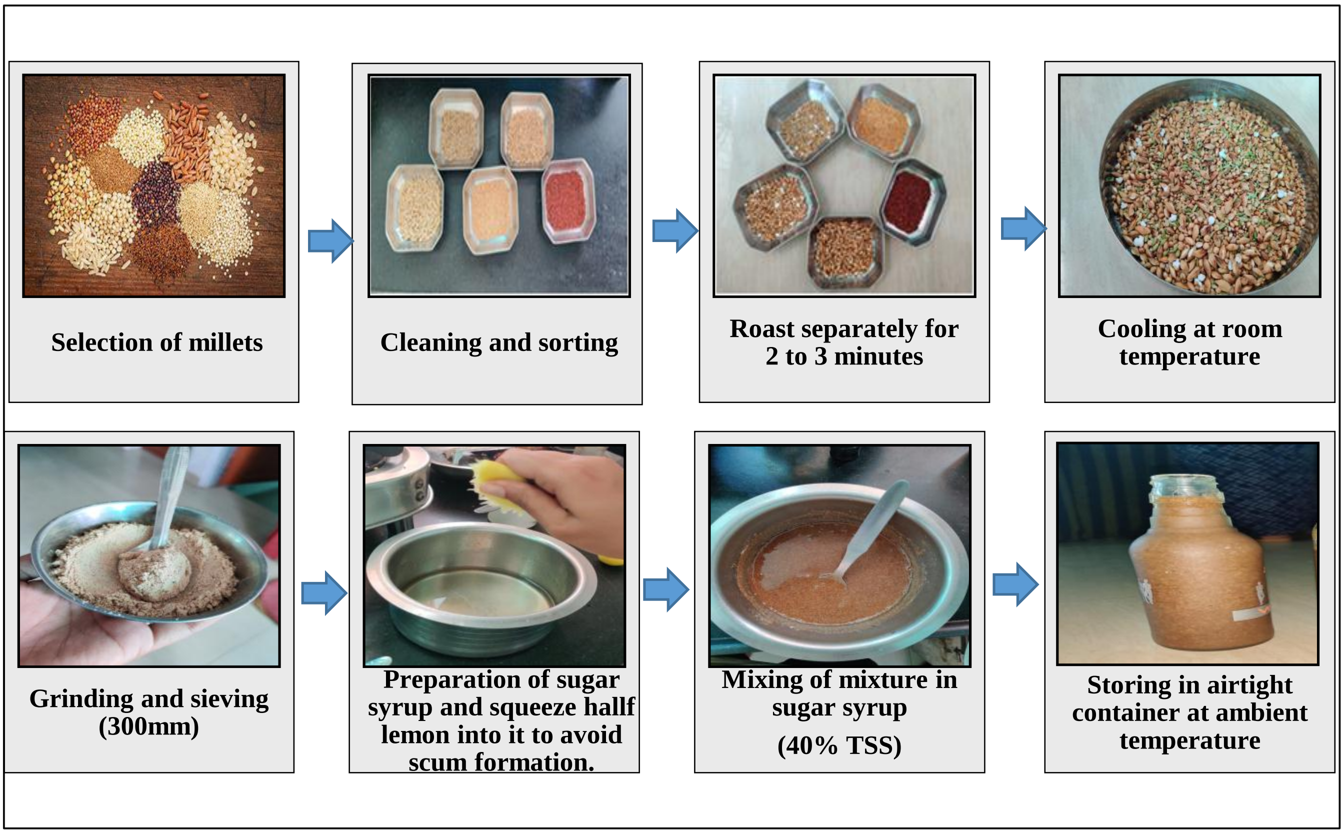


Figure 3.1. Development of *Panch millet sattu*

Procedure for manufacturing *Millet Thandai*:

1. Good-quality millets were selected and processed.
2. Ragi and foxtail millets were cooked separately for 2–3 minutes to increase flavour.
3. Roasted millets were allowed to cool to ambient temperature.
4. All the *thandai* ingredients were ground together and filtered through a 300-mm sieve to create a fine powder.
5. Sugar syrup was formed with a one-and-a-half-string consistency.
6. The fine mixture was mixed into the sugar syrup when syrup was cooled.
7. The prepared *Millet thandai* was packed in a sterilised glass bottle and stored in a cool, dry place.
8. *Millet Thandai* was served with 2 tbsp. (20g) of syrup in 200 ml (1 glass) of chilled pasteurised milk.

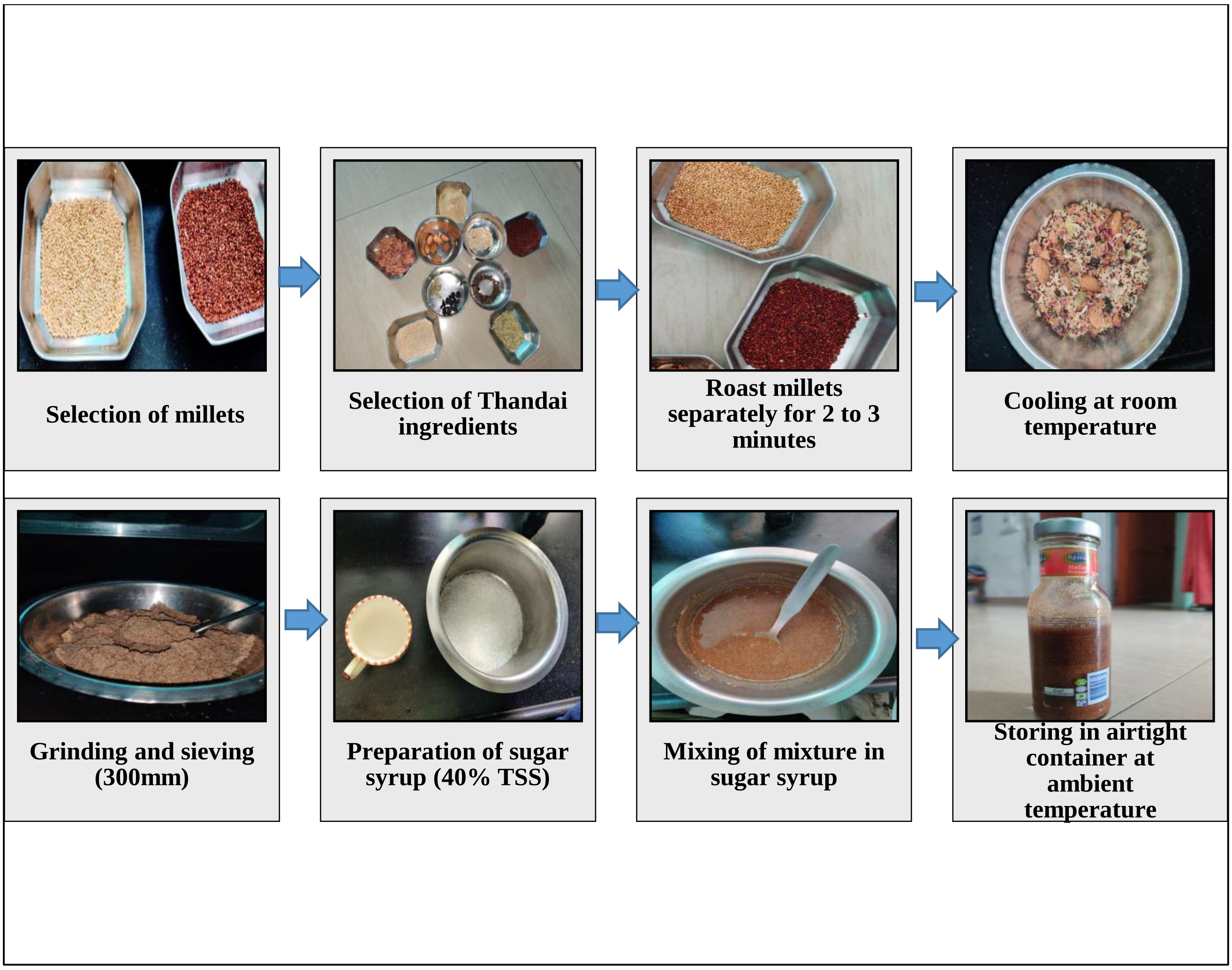


Figure 3.2. Development of *Millet Thandai*

b) **Procurement of raw materials:** A single batch of some millets, including pearl millet, foxtail millet, sorghum millet, ragi, and barley, was purchased from the local market. Additionally, all other necessary raw ingredients for beverage preparation were procured from the local markets of Udaipur as needed throughout the study. This ensured consistency in ingredient sourcing and facilitated efficient procurement throughout the study.

c) **Preparation of recipe-** *Thandai* is a traditional Indian cold beverage made with a blend of milk, nuts, seeds, spices, and sweeteners. *Sattu* is a flour made from roasted grains like barley or chickpeas, commonly used in Indian cuisine to prepare beverages. In the present study, pearl millet, ragi, foxtail millet, barley, and sorghum millet for *Panch Millet Sattu* and ragi and foxtail millet for *Millet Thandai* were mixed in three different proportions as shown in the table given below:

Table 3.1: Ingredients used in different *Panch Millet Sattu* samples

Ingredient	**Treatment 1**	**Treatment 2**	**Treatment 3**
Roasted Foxtail millet (g)	15	10	05
Roasted Ragi (g)	10	15	15
Roasted Jowar (g)	10	15	10
Roasted Pearl millet (g)	15	10	25
Roasted Barley (g)	10	15	10
Roasted Fennel seeds (g)	10	05	05
Sugar (g)	80	80	80
Water (ml)	100	100	100

Table 3.2: Ingredients used in different *Millet Thandai* samples

Ingredient	**Treatment 1**	**Treatment 2**	**Treatment 3**
Roasted foxtail millet (g)	24	20	26
Roasted ragi (g)	16	20	14
Almond (g)	5	5	5
Poppy seeds (g)	2.5	2.5	2.5
Dried rose petals (tsp)	2-3	2-3	2-3
Black pepper (g)	5	5	5
Cardamom (g)	5	5	5
Muskmelon seeds (g)	5	5	5
Munakka (g)	5	5	5
Fennel seeds (g)	2.5	2.5	2.5
Sugar (g)	80	80	80
Water (ml)	100	100	100

d) **Selection of panel:** The organoleptic scoring was completed by a panel of 30 semi-trained judges selected from the College of Community and Applied Sciences, MPUAT, Udaipur.

e) **Sensory evaluation:** The prepared products were assessed for sensory characteristics using a 9-point hedonic rating scale (Rangana, 2002). Sensory evaluation is a scientific discipline that involves the objective assessment of food products and their attributes through the human senses. It encompasses the systematic observation, measurement, and interpretation of sensory stimuli, such as appearance, aroma, flavour, consistency, and overall food quality, to understand consumer preferences, product quality, and sensory characteristics. Both of the beverages were evaluated organoleptically by semi-trained panel of judges.


Plate 3.1: Sensory evaluation of the beverages by Panel members

3.2 Physico-chemical and Nutritional Analysis of Millet-based beverages

The developed millet beverages underwent analysis using standard techniques and methods.

3.2.1 Physico-chemical analysis-

a) **TSS-** The content of total soluble solids (TSS) of Millet beverage samples was determined in Department of Dairy and Food Technology using a digital hand refractometer "ATAGO" of 45-93 percent (Brix). As per the given instructions, it was corrected at 20º C and precaution was taken to wash the prism of refractometer with distilled water and wipe with dry clean clot before every reading.

Plate 3.2: Refractometer for TSS determination

b) **pH-** It is the measurement of the logarithm of inverse of hydrogen ion concentration in the solution.

$$pH = -\log(H+)$$

Where,

(H+) = hydrogen ion concentration (g/lit)

The (ELICO LI 612) pH analysers from Department of Dairy and Food Technology was used for this purpose, to calibrate the pH analyser it was ensured that calibration solutions covering the sample's pH range. The analyser was powered ON and entered calibration mode. The electrode was cleaned, immersed in each calibration solution of 7-pH and 4-pH, and the readings were stabilized before adjusting the analyser to match the known pH values. This process was repeated for each solution. After exiting calibration mode, the electrode was rinsed, and routine maintenance was performed.

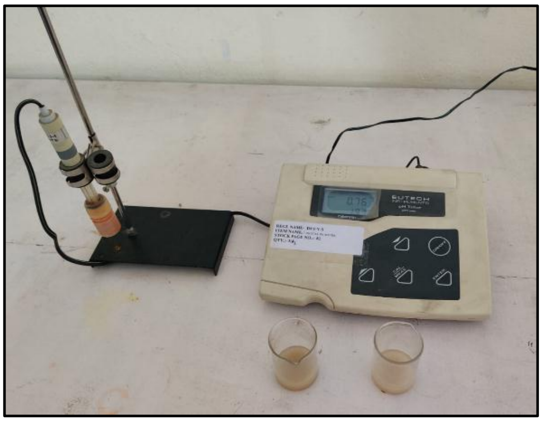


Plate 3.3: pH determination

3.2.2 Proximate analysis-

a) Moisture-

Moisture content present in food items is determined by the amount of solid compounds and liquids other than water present in each product. This is calculated by weighing the product before and after it's exposed to a humidity chamber, with the resulting number representing the percentage of moisture content. As water evaporates, its weight decreases, while the weight of solid compounds and non-water liquids remains constant. Besides analysing the chemical makeup of food components, knowing the moisture content helps estimate the product's shelf life duration on the market (AOAC 1990).

Method: A fresh sample of the product, weighing ten grams, was weighed three times in a petri-dish that had been pre-weighed. Subsequently, it underwent drying in an oven at 60ºC, followed by cooling in a desiccator, and reweighing. The heating and chilling process was repeated until a constant weight was reached. The moisture percentage was subsequently calculated using a predetermined procedure.

$$\textbf{Moisture (g/100g)} = \frac{initial\ weight - Final\ weight}{weight\ of\ the\ sample}\ X\ 100$$

Plate 3.4: weighing of samples for moisture analysis

b) Crude protein:

Using the Micro Kjeldahl Method to measure the nitrogen level present in beverages, the protein content was determined (AOAC, 1990). Samples were digested with a strong acid to release nitrogen and titrated with suitable titration technique. The crude protein content of the created drinks was calculated by multiplying the samples' nitrogen levels by a factor of 6.25.

Method-

Digestion: for completing digestion process placed 100 mg of the moisture free sample and 0.5g of digestion mixture in the Kjeldahl flask. Add 2ml of concentrated sulfuric acid (AR grade) and keeping one sample blank (without sample). The samples were digested by heating them on a digestion rack until the contents were digested and a clear solution was formed, then cooling them.

Distillation: Kelplus Classic- DX VATS (B) Micro Kjedahl was used for distillation. The distillation flask was filled with boiling water, and the steam was allowed to travel through the condenser. The equipment was washed 2-3 times with steam before the digesting mixture was relocated to the distillation tube. The digesting tube was rinsed three to four times with distilled water. 10 ml of 40% NaOH, 5 ml of boric acid, and a few drops of indicator were poured to a conical flask and put beneath the condenser, ensuring that the tip of the condenser contacted the solution. The flask was used to collect the freed ammonia (light green), and the distillate was collected in a 15 ml sample.

Titration: standardized 0.02 N HCl was taken in a burette and distilled was diluted content with 50 ml water. Titration was done until the grey/pink colour obtained and the amount of acid consumed was recorded.

$$\textbf{Nitrogen \%} = \frac{(ml\ HCl\ in\ determination - blank)x\ N\ of\ HCl\ x\ 14}{weight\ of\ sample\ (mg)} X\ 100$$

Protein% = Total nitrogen % X General factor 6.25

Plate 3.5: Titration for estimation of crude protein

c) Crude fat:

The Soxhlet's Extraction Method on the Socsplus System was used for the estimation of crude fat. The crude ether extract of moisture free samples was used to assess the fat content of the developed millet beverages.

Method: A weighed quantity of the moisture free sample (5 g) was put into a thimble. The thimble was placed in the thimble holder which was placed in a beaker which had been weighed and 80ml of petroleum ether (60-80°) was poured into the beaker. The temperature was set to 100 °C, and the system was filled with beakers. The temperature was increased to the recovery temperature, which was twice the starting boiling temperature, after 120 minutes of operation. Thus, rinsing was done twice to remove any remaining fat from the sample. The beakers were taken out and put in the hot air oven. The thimble holders were taken out and the beakers weighed. The following formula was used to calculate the sample's fat content:

$$\textbf{Fat (g/100g)} = \frac{\textit{weight of flask with extracted fat} - \textit{weight of empty flask}}{\textit{weight of sample}(g)} X\ 100$$

Where,

A = weight of empty flask (g)

B = weight of flask + fat (g)

B-A = weight of fat (g)

Plate 3.6: Soxhlet Apparatus for estimation of crude fat

d) Ash

When organic matter is burned, an inorganic residue left behind, and this is what makes up food's ash content. A measurement of the entire mineral content of the food is the total ash estimation (AOAC, 1990).

Method: A 5g moisture free sample was weighed in an earlier heated, cooled and weighed crucible. The sample was thoroughly charred on a hot plate before being heated for five hours at 600 ºC in a muffle furnace. After cooling in desiccator, the crucible was weighed. The procedure was continued until the obtained ash was nearly white or grey in colour and had a constant weight. Using the following formula, the ash content of the samples was calculated:

$$\text{Ash (g/100g)} = \frac{\textit{weight of ash (g)}}{\textit{weight of sample taken (g)}} X\ 100$$

Plate 3.7: Hot plate and Muffle furnace for determination of ash

e) Crude fibre:

The amount of fibre was calculated using the acid- alkaline digestion method.

Crude fibre is a loss on ignition of dried residue remaining after digestion of sample with 1.25% sulfuric acid and 1.25% sodium hydroxide solutions under specific conditions (AOAC, 1990).

Method: five grams of sample that was free of moisture and fat was put in 200 ml 1.25 percent sulfuric acid in a 500 ml beaker and boiled for 30 minutes. The volume was maintained constant by adding hot distilled water while the mixture was boiling and this was filtered through Muslin cloth and the leftover material was thoroughly rinse with hot distilled water to remove any remaining acid. The residue was then transferred to the same beaker and heated in 200 ml of 1.25 percent sodium hydroxide solution for 30 minutes. The samples were filtered through Muslin cloth. The filtrate was then washed with 50 ml of alcohol and ether and rinse with hot water distilled water until it was free of alkali. The residue was then put into the crucible (W1) and dried for 2 to 3 hours at 130º C then cool and weighed (W2). The dried residue in the crucible was fired in a muffle furnace at 600º C for 1 to 2 hours until it was change to ash. Ash was cooled and weighed (W3). After all the procedures crude fibre was calculated using the formula given below:

$$\textbf{Per cent crude Fibre (g/100g)} = \frac{(w2-w1)-(w3-w1)}{weight\ of\ sample\ (g)} X\ 100$$

Where,

W1= weight of empty crucible

W2= weight of crucible with dry residue

W3= weight of crucible with heated residue

Plate 3.8: Estimation of crude fibre

f) Carbohydrates:

Carbohydrate content of the sample was determined by the difference method, i.e. sum of moisture, protein, crude fibre, fat and ash subtracted from 100. The total carbohydrate content is calculated using the formula given below:

Carbohydrates (g/100g) = 100- *(moisture + crude fibre + ash + crude protein +crude fat)*

g) Energy:

Energy values for the samples were determined using physiological fuel values of 4 kcal for protein, 9 kcal for fat and 4 kcal for carbohydrates.

Energy (kcal/100g) = [(% Protein x 4) + (% Carbohydrates x 4) + (% Fat x 9)]

3.2.3 Mineral estimation:

a) Iron:

Iron content was analysed by using atomic absorption spectrophotometer (Bishnoi and Brar 1988).

Procedure: Diluted sample was drawn up through a capillary in the atomizer burner assembly and transformed into a fine spray buyer stream of compressed air. This fine spray then enters a monochromatic wave that has been set at the wavelength of the element to be determined and falls on the photo multiplier tube (photocell) after large droplets of Acetylene are condensed and mixed with it and

Burned in a long flame. A galvanometer is used to measure the electrical energy that this tube converts from light radiation.

$$\textbf{Fe (ppm)} = \frac{ppm\ Fe\ (from\ caliberated\ curve) x\ vol.}{weight\ of\ sample}$$

Where,

Vol. = Total volume of sample digest (ml)

Convert the ppm into mg/g dividing by 0.001

Plate 3.9: Iron estimation by AAS

b) **Calcium:**

It was calculated using the titrimetric method (Cheng and Bray, 1951). The solution of Ethylene Diamine Tetra Acetic Acid (EDTA) solution of (0.01N) was prepared and standardized against standard calcium chloride (0.01N) solution.

Procedure:

In a conical flask 5-10 ml of digested sample was taken in triplicate. 1ml of 4N sodium hydroxide and 50 mg ammonium perchlorate indicator were added to the mineral solution. Titration with 0.01. N EDTA solution was performed on the sample. The colour change from the orange red to lavender purple clearly indicates the readings of the end point. The calcium content was calculated using the following formula.

$$\textbf{Calcium (mg/100g)} = \frac{VEDTA\ \ X\ NEDTA\ X\ 20\ X\ 100}{weight\ of\ sample\ (g)}$$

Where,

V = volume of EDTA

N= Normality of EDTA

Plate 3.10: Calcium estimation by titrimetric method

3.3 Packaging of millet based beverages:

Developed millet based non fermented beverages were packed in clean, hygienic, colourless and transparent bottles (FSSAI, 2011).

3.4 Shelf life estimation:

The prepared products were stored in glass bottles and were evaluated for their shelf life. The shelf life of the products were observed in terms of its (quality evaluation) for a maximum of 60 days at regular intervals that is at 0, 15, 30, 45 and 60 days.

a) Microbial assessment of non-fermented millet based beverages:

Microbial estimation is the perfect quality assessment protocol performed in quality analysis of food products. However, in non-fermented millet based beverage product, it is a mandatory one. Total plate count was done in department of microbiology of RCA College.

Total plate count: Microbial analysis was done to determine total plate count of the non-fermented beverages on nutrient agar media by the method recommended by Harrigan and Mc.Cance, (1966). Plate count Agar Media was prepared and sterilized at pressure 15 psi for 15 minute. Serial dilutions were made up to 10 times and microbial counts of 10^{-9}, 10^{10}, dilutions were analysed and 1 µl of the dilution was taken in a petri plate and 15 to 20 ml media was poured into the plate and the plate were incubated at 37º C for 48 hours and colonies were counted manually.

$$\textbf{Total bacterial count (cfu/mL)} = \frac{no.of\ colonies\ X\ dilution\ factor}{mL\ of\ aliquot}$$

Plate 3.11: Microbial assessment (TPC) for estimating shelf life of beverages

3.5 Data analysis

The data was analysed with the application of mean, standard deviation and ANOVA.

According to the studies objectives, all the data was statistically analysed mean ± SD was used to express the nutrition composition of the Millet based beverages. To analyse the acceptability of the beverages with various formulation, the analysis of variance (ANOVA) one way classification was employed.

Mean (X)

$$\textbf{Mean } (\bar{X}): \quad \bar{X} = \frac{1}{n} + \sum_{i=1}^{n} Xi$$

Where, x= observation

n= number of observation

i = 1, 2, 3………………….

Standard Deviation (SD)

$$SD\ (\sigma) = \sqrt{\frac{\sum_{i=1}^{n} X^2 - \ (\sum_{i=1}^{n} Xi)^2}{n-1}}$$

ANOVA one way classification

Data obtained from the sensory evaluation, nutrient analysis and mineral analysis were subjected to analysis of variance techniques (one way classification).

Table 3.3: ANOVA for one-way classification

Source of Variance	**Degree of Freedom (d.f.)**	**Sum of Squares**	**Mean Squares**	**Variance Ratio (F)**
Treatment	K -1	SST	$MST\frac{SST}{K-1}$	$F=\frac{MST}{MSE}$
Error	rk-k	SSE	$MSE = \frac{SSE}{rk-k}$	$\sim F\ [(K-1), ek-1)]$
Total	rk-1	TSS	-	

Sum of square due to treatment (SST)

$$SST = \frac{\sum_{i=1}^{k}(\sum_{j=1}^{r} X_{ij})^2}{r} - \frac{\sum_{i=1}^{k}(\sum_{j=1}^{r} X_{ij})^2}{rK}$$

Total sum of square (TSS):

$$\mathbf{TSS} = \frac{\sum_{i=1}^{k}(\sum_{j=1}^{r} X_{ij}\ \sum_{i=1}^{k}(\sum_{j=1}^{r} X_{ij})^2}{rk}$$

Sum of square due to error (SSE)

$$SSE = TSS - SST$$

Critical difference (CD): The critical difference was calculated for finding out the significant difference the corresponding two mean values:

$$CD = Sem.\sqrt{2}\,.t_{ab} \text{ at 5\%T and 1\% T LS and error d.f.}$$

Standard error for mean:

$$Sem = \sqrt{\frac{EMS}{r}}$$

Where,

EMS = Error mean square

X_{ij} = value of i^{th} treatment in j^{th} replication r= Number of replications

K= treatment

RESULTS AND DISCUSSION

The experimental and provable explanation of the data obtained throughout the course of the investigation is critical to evaluating any study's effectiveness. Results obtained throughout the course of the study were submitted to appropriate statistical computations, tabulated, and presented systematically through organised and pertinent information. The current study focused on the "Development and standardization of Millet-Based Non-Fermented Beverages". The present study findings have been described under the following headings and subheadings:

4.1 DEVELOPMENT AND STANDARDIZATION OF MILLET BASED BEVERAGES

Unhealthy beverage consumption is a growing concern in India, with sugary drinks and processed juices contributing to health issues like obesity and diabetes. To address this, millet based beverages are introduced as healthier alternatives for people of all ages. This initiative seeks to promote better dietary choices and combat the negative health effects. In the present investigation, a single batch of some millets, including pearl millet, foxtail millet, sorghum millet, ragi, and barley, were purchased from the local market to prepare non-fermented beverages, namely *Panch Millet Sattu* and *Millet Thandai*. In the preparation of millet-based beverages, millets were incorporated into different combinations. After a number of trials, both of the beverages were standardized. The detailed procedure of standardization for each beverage is described below:

Panch millet sattu

Sattu is a healthy, sweetish summer powder that is consumed by making it drinkable. It is made with roasted gram flour, jowar, and *dhani* (puffed barley). It gives rapid freshness, provides energy and hydration, supports digestion, maintains healthy glucose levels, improves hair and skin health, helps in weight loss, lowers the cholesterol level, and has a has a relatively long shelf life.

In the present study, pearl millet, ragi, foxtail millet, barley, and sorghum millet were incorporated for manufacturing *Panch millet Sattu*. The amount and ingredients used in the preparation of beverages are explained in Table 4.1, given below:

Table 4.1: Ingredients used in *Panch Millet Sattu*

Ingredient	Amount (per cent)
Roasted Foxtail millet	4
Roasted Ragi	6
Roasted Jowar	6
Roasted Pearl millet	4
Roasted Barley	6
Roasted Fennel seeds	2
Sugar	32
Water	40

The entire *Panch Millet Sattu* preparation procedure took about 30 minutes. Initially, all of the basic ingredients weighed 70 g, including 10 g of foxtail millet, 15 g of ragi, 15 g of jowar, and 15 g of barley, 10 g of pearl millet, and 5 g of fennel seeds. After roasting these ingredients for 2-3 minutes each to liberate their aromas, their total weight was decreased to 68 g. After roasting, the millets and fennel seeds were allowed to cool before mixing and powdering. In parallel, a sugar syrup was made with a 2:1 sugar-to-water ratio to reduce moisture deterioration, and half a lemon was added to avoid crystallisation. The powdered components were carefully mixed into the syrup to achieve a smooth consistency with no lumps. The prepared beverage had a semi-solid consistency, and its final cooked weight was 274.8 g.

Millet Thandai

Thandai is a traditional drink with a fragrant aroma and sweet perfumed flavours of rose, cardamom, and saffron, combined with some pungency from black pepper. It is prevalent in northern India, and it is predominantly made during the Holi festival of colours. The major ingredient in this beverage is a sweetened paste made of nuts, seeds, and a few spices. This paste is then mixed with milk to create a delightful drink. It has cooling and hydrating properties, is nutritious and good for the immune system, and has a good shelf life.

In the present study, ragi and foxtail millet were incorporated for manufacturing *Millet Thandai*. The amount and ingredients used in the preparation of beverages are explained below in Table 4.2:

Table 4.2: Ingredients used in *Millet Thandai*

Ingredient	Amount (per cent)
Roasted Foxtail millet	8
Roasted Ragi	8
Almond	2
Poppy seeds	1
Dried rose petals	1.2
Black pepper	2
Cardamom	2
Muskmelon seeds	2
Munakka	2
Fennel seeds	1
Sugar	32
Water (ml)	40

The entire *Millet Thandai* preparation procedure took about 30 minutes. The initial weight of *Thandai* ingredients was 72 g. Both ragi and foxtail millet were roasted together for 2-3 minutes each to obtain flavour and aroma; there was no change in weight deduction after roasting. Both millets were cooled and ground after they were mixed with the other remaining ingredients. In parallel, a sugar syrup was made with a 2:1 sugar-to-water ratio to reduce moisture deterioration. The powdered components were carefully mixed into the syrup to achieve a smooth consistency with no lumps. The beverage maintained a semi-solid consistency, and its final cooked weight was 256.43 g.

Sensory evaluation of beverages

Perceivable sensory features have traditionally been seen as the determining element in the acceptance and pleasure of foods by people, and they have an advantage over other equally essential nutritional and safety factors. These sensory results were awarded by panel members for independent sensory characteristics and overall acceptance. It followed the additional statistical analysis, the analysis of variance (ANOVA), for the sensory qualities of consumable drinks in different amounts.

A panel of 30 judges used a nine-point hedonic scale (Rangana, 2002) to evaluate the sensory properties of the developed beverages under controlled laboratory circumstances. Sensory ratings granted by panel members for different sensory qualities and overall acceptability were aggregated and shown in Table 4.3 and 4.4. The results clearly show that sample T2 from both *Panch Millet Sattu* and *Millet Thandai* achieved a mean overall acceptability score of more than 8.0. This demonstrated that the T2 sample was assigned an extraordinary likeness by panel members.

Table 4.3: Sensory evaluation of *Panch Millet Sattu*

Sample	Sensory attributes Mean ± SD					
	Colour	Flavour	Taste	Consistency	Appearance	Overall Acceptability
S1	7.2 ± 0.92	7.3 ± 0.95	7.83 ± 0.94	7.2 ± 0.99	7.06 ± 0.82	7.51 ± 0.78
S2	8 ± 0.78	7.9 ± 0.82	8.23 ± 0.67	7.9 ± 0.75	7.8 ± 0.92	8.2 ± 0.66
S3	6.9 ± 0.92	7.6 ± 0.81	7.43 ± 0.93	7.5 ± 0.97	7.26 ± 0.86	7.13 ± 0.77
S.E.	0.104	0.094	0.096	0.101	0.096	0.09
C.D.	0.31	0.31**	0.31**	0.33**	0.31**	0.26

All the values are mean ±standard deviation of three observations. SE- Standard error, **Significant at 1% level of significance

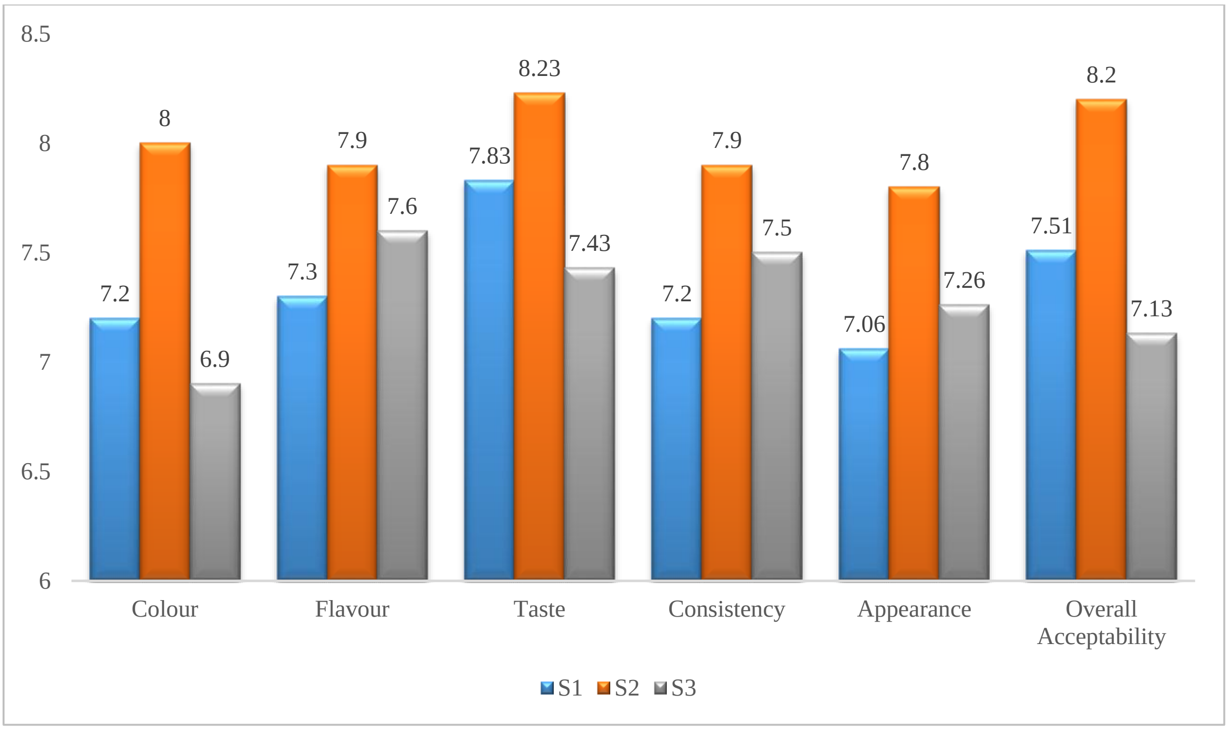


Fig. 4.1: Sensory scores of *Panch millet Sattu*

Further table 4.3 and fig. 4.1 reveals that S2 had the highest colour score (8 ± 0.78), followed by S1 (7.2 ± 0.92) and S3 (6.9 ± 0.92). Similarly S2 had the highest flavour score (7.9 ± 0.82), followed by S1 (7.3 ± 0.95) and S3 (7.6 ± 0.81). S2 had the highest taste score (8.23 ± 0.67), followed by S1 (7.83 ± 0.94), and S3 (7.43 ± 0.93). Consistency for *panch millet sattu* drink was found to be acceptable for S2 (7.9 ± 0.75), followed by S1 (7.2 ± 0.99), and S3 (7.5 ± 0.97). S2 received the highest score for appearance (7.8 ± 0.92), followed by S1 (7.06 ± 0.82) and S3 (7.26 ± 0.86). Overall acceptance of *Panch millet sattu* was reported to be extremely satisfactory for S2, i.e., (8.2 ± 0.66), followed by S1 (7.51 ± 0.78) and S3 (7.13 ± 0.77).

A significant difference was seen between variants S1, S2, and S3 for flavour, texture, taste, and appearance in *Panch millet sattu* ($p \leq 0.01$), except for colour and overall acceptability which was non-significant ($p \geq 0.05$).

Table 4.4: Sensory evaluation of *Millet Thandai*

Sample	Sensory attributes Mean ± SD					
	Colour	Flavour	Taste	Consistency	Appearance	Overall Acceptability
T1	6.3±0.92	7.07±0.94	7.1±0.76	6.03±0.72	7.17±0.83	7.4±0.77
T2	8.1±0.78	8.0±0.67	8.5±0.73	8.2±0.85	8.03±0.85	8.33±0.71
T3	6.87±0.73	7.6 ±0.94	7.1±0.86	7.2±0.85	6.9±1.03	7.3±0.83
SE	0.15	0.16	0.14	0.15	0.33	0.09
CD	0.30	0.31	0.29	0.29	0.11	0.28

All the values are mean ±standard deviation of three observations. SE- Standard error Non-significant

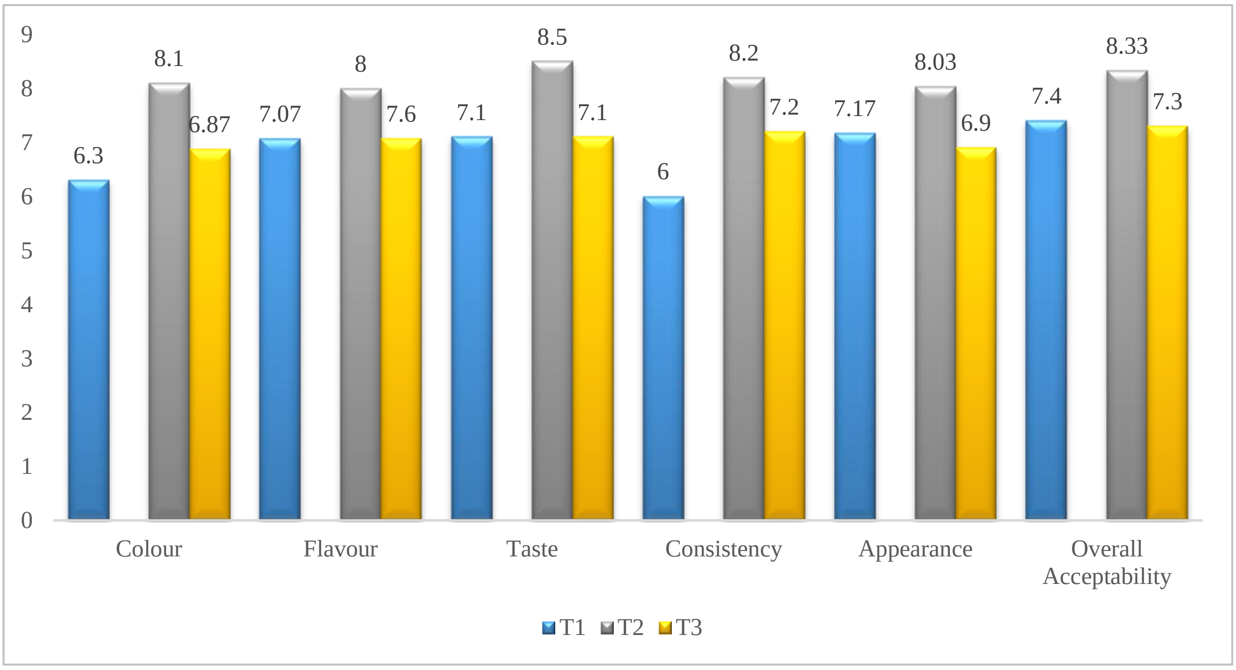


Fig. 4.2: Sensory scores of *Millet Thandai*

The data shown in Table 4.4 and fig. 4.2 indicate that T2 received the highest scores in multiple quality attributes. T2 had the highest colour score (8.13±0.77), followed by T1 (6.33±0.92) and T3 (6.86±0.73). Similarly, T2 scored 8.0 ±0.66 for flavour, followed by T1 7.07 ±0.94 and T3 with 7.6±0.94. T2 had higher score 8.5±0.73 in taste, followed by T1 7.1±0.75 and T3 7.13±0.86. T2 had the greatest consistency rating (8.2±0.84), followed by T1 (6.03±0.71) and

T3 (7.2±0.84). T2 obtained the highest appearance score of 8.03±0.85, followed by T1 (7.16±0.83) and T3 (6.9±1.02). Overall acceptance of *Millet Thandai* was reported to be extremely satisfactory for T2, i.e., (8.33 ± 0.71), followed by T1 (7.4 ± 0.77) and T3 (7.26 ± 0.82).

No significant difference was seen between variants T1, T2, and T3 for all sensory qualities in *Millet Thandai* ($p \leq 0.01$).

Plate 4.1: Standardized non-fermented Millet beverages (*Panch millet sattu* and *Millet Thandai*)

Hence, the addition of nuts and herbs in both *Panch Millet Sattu* and *Millet Thandai* played a crucial role in shaping the sensory characteristics of the beverages. For *Panch Millet Sattu*, fennel seeds helped to balance and enhance the aroma, making the millet's natural scent more acceptable. In *Millet Thandai*, the reduction of millet proportion and emphasis on traditional *thandai* ingredients allowed the beverage to maintain its familiar flavour profile while integrating millets in a subtle manner. Both approaches effectively used additional ingredients to create beverages that appeal to consumer preferences, demonstrating the importance of formulation adjustments in achieving optimal sensory qualities.

4.2 Physico-chemical and nutritional analysis of developed millet based non fermented beverages:

Roasting was the cooking technique used to prepare millet beverages. This technique may influence nutritional profile of millet-based beverages due to several reasons:

a) Maillard Reaction: Improves flavour and colour, but may affect protein and amino acid nutrition.

b) Nutrient Availability: Enhances mineral availability by breaking down anti-nutritional substances.

c) Enzyme Activity: Deactivates enzymes that break down nutrients, retaining lipid content.

d) Moisture reduction concentrates nutrients and enhances shelf life.

e) Structural changes: Increases digestibility by breaking down complex carbs.

f) Heat-Sensitive Nutrients: Vitamin C and several B vitamins, for example, may deteriorate when exposed to high temperatures.

The most acceptable beverages, *Panch Millet Sattu* (S2) and *Millet Thandai* (T2), were subjected to the nutritional analysis for physico-chemical and nutritional analysis, which included pH, TSS, proximate composition (moisture, ash, crude fat, crude fibre, protein, carbohydrates, and energy), and mineral estimation (iron and calcium). All observations were derived on a dry-weight basis. No preservative, colour and chemical substance was added in both the beverages to improve shelf life of beverages. The results are expressed as per 100g of prepared beverages in the Table 4.5- 4.7 are discussed below:

1. Physico-chemical analysis:

a) Total Soluble Solids:

A digital hand refractometer 'ATAGO' of 45–93 percent brix was used to determine the total soluble solids of the *Panch Millet Sattu* and *Millet Thandai* immediately after manufacturing. Table 4.5 and fig. 4.5 illustrates that, the TSS of *Panch Millet Sattu* was 70 ºBrix and *Millet Thandai* was 71.1 ºBrix. Sunda, N.R. (2021), suggested that 70 ºBrix TSS may present in sharbat, and in guidelines of FSSAI, 2019, it is also suggested that the TSS of sharbat should be more than 65 ºBrix which is good for preservation, and maintain texture, consistency, and proper dilutions.

2. pH value:

The pH of developed beverages were determined using an 'ELICO LI 612' pH analyser shortly after preparation. Table 4.5 and fig. 4.3 illustrates that the pH of *Panch Millet Sattu* was 4.36, indicating mild acidity due to the addition of a lemon to avoid crystallisation. The pH of *Panch Millet Sattu* was found to be quite similar (4.52 ± 0.01) to Manasa *et al*. (2022).

On the other hand, the pH of *Millet Thandai* was 8.38, indicating that it was alkaline in nature. This may be due to presence of both the millets i.e., ragi and foxtail and the alkalinity of *Thandai* ingredients like nuts, poppy seeds, and rose petals. In a study by Manasa *et al*. (2022), it was also found that unfermented pearl millet beverage had a pH of 6.57 ± 0.01. In another study conducted by Sravanthi (2022), it was defined that by incorporating millet in beverage, the pH range changes from 6.80 to 6.20.

Table 4.5: Physico-chemical analysis of developed beverages

S. no.	Physico-chemical analysis	Panch millet sattu	Millet thandai
1	TSS	70 ºBrix.	71.1 ºBrix.
2	pH	4.36	8.38

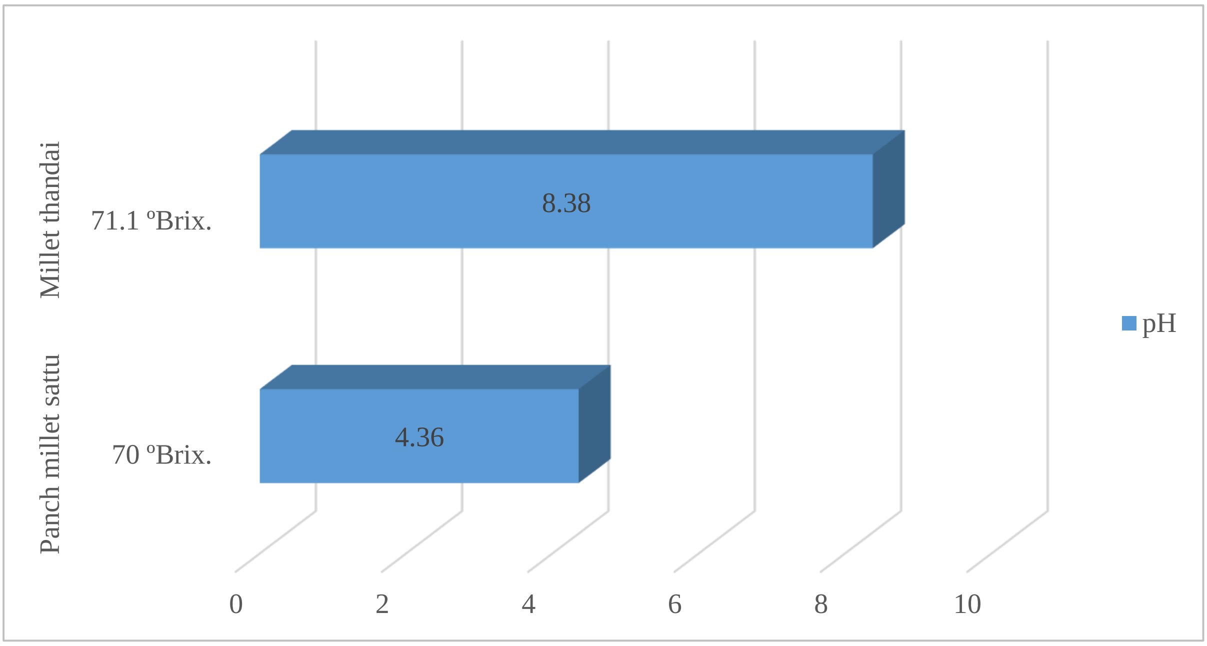


Fig. 4.3: Physico-chemical analysis of developed beverages

3. Proximate composition:

The table 4.6 and fig. 4.4 demonstrated the proximate composition of developed millet based beverages.

a) Moisture:

The moisture content of both beverages was analysed using the AOAC (1990) method on wet basis. The moisture content present in *Panch Millet Sattu* was 62.12 ± 1.99. In a study by S. and Narayansamy Sangeetha (2021), it was found that foxtail millet beverage has 72 percent moisture. *Panch Millet Sattu* has lower moisture content due to roasting and grinding, while foxtail millet beverages have greater moisture due to additional water.

On the other hand, the moisture content in *Millet Thandai,* was 71.58 ± 1.23 and in a similar study conducted by Chawla *et al*. (2018), it was found that the market samples of *Thandai* syrup have 79 to 80 percent moisture in 100 g of syrup.

4. Crude protein:

The crude protein content of developed beverages was analysed using the Micro Kjehldahl Method. The crude protein of *Panch Millet Sattu* was 4.38 ± 1.55, which provides 0.86 g in one serving. According to IFCT (2017), the crude protein value for one serving is 0.85 g, which is quite similar to the one serving of *Panch Millet Sattu*.

The crude protein content of *Millet Thandai* was 1.07 ± 0.25, and for one serving, it provided 0.2 g. According to IFCT (2017), the crude protein value for one serving is 0.36 g; hence, it was observed that the protein content of *Millet Thandai* has very less variation in comparison to one serving by IFCT. This variation may be due to processing method.

5. Crude fat:

The crude fat content of both beverages was analysed using Soxhlet's extraction method of 'Socsplus Apparatus'. The crude fat content of prepared *Panch Millet Sattu* was 2.74 ± 0.01, and for one serving, it was 0.68 g. The crude fat present in one serving of *Panch Millet Sattu* according to IFCT (2017), is 0.44 g. The crude fat content of *Millet Thandai* was 5.18 ± 0.06, and for one serving, it was 1.02 g. The crude fat present in one serving of *Millet Thandai* according to IFCT (2017), is 0.74 g. The results obtained are higher in comparison to IFCT.

6. Ash:

The ash content found in *Panch Millet Sattu* was 0.94 ± 0.10 g, it was defined by Apaliya *et al.* (2017) that the average ash content present in fermented millet beverages is 0.28 ± 0.01. The rise in ash content due to millet roasting mainly causes a loss in the concentration of minerals as moisture and volatile organic components, as well as the heat destruction of organic matter (Singh *et al.,* 2018).

The ash content found in *Millet Thandai* was 1.46 ± 0.17; it was suggested by Chawla *et al*. (2018) that market samples of *Thandai* contain 0.86 ± 0.01 percent of ash. The results obtained for the *Thandai* beverage show that *Millet Thandai* has a higher ash content in comparison to the market-available samples of *Thandai*. This is due to the incorporation of millets in *Millet Thandai.*

7. Crude fibre:

The crude fibre content was determined using the method of AOAC (1990) for both beverages. The crude fibre of *Panch Millet Sattu* was 05 ± 0.05, and in one serving, it provides 0.2 g, but in one serving from IFCT (2017), it provided 0.14 g. It was noted that the crude fibre of *Panch Millet Sattu* was higher in comparison to the IFCT's one serving. This can be said as on roasting of millets, the crude fibre content and their digestibility increase (Sudha *et al.,* 2021). The crude fibre content in *Millet Thandai* was 0.52 ± 0.24, and in one serving, it provided 0.1 g, but in one serving from IFCT (2017), it provided 0.08 g. The results obtained for *Millet Thandai* are quite similar to the IFCT's one serving.

8. Carbohydrates:

By using the difference method, the carbohydrate content of both beverages was defined. The carbohydrate content found in *Panch Millet Sattu* was 24.63 ± 2.55 and in *Millet Thandai* it was 20.15 ± 1.32. According to (FSSAI, 2019) it is suggested that 20-30 percent carbohydrates are present in one serving of RTS beverages.

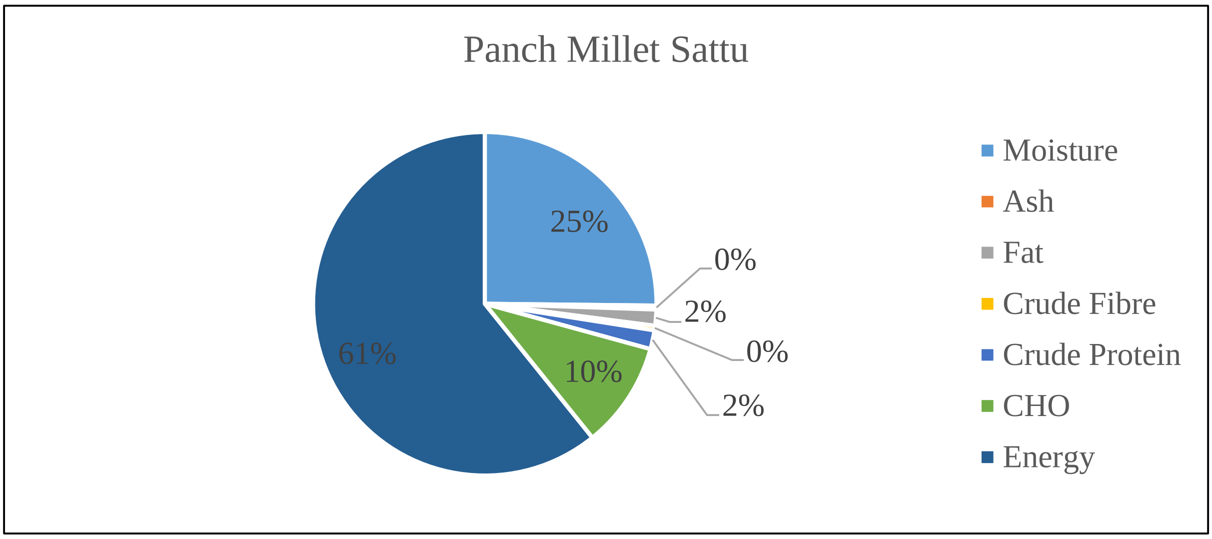
9. Energy:

The kilocalorie content of *Panch Millet Sattu* was 150 ± 16.40 and that of *Millet Thandai* was 132 ± 3.98. One serving of *Panch Millet Sattu* provide 30 kcal of energy, similarly in one serving of *Millet Thandai* gives 64 kcal of energy. The energy content of both beverages are more or less similar to the energy present in squash i.e., 160 kcal per 100 g (FSSAI, 2019).

Table 4.6: Nutritional content of developed beverages (per 100 g)

S. no.	Nutritional analysis	Panch millet sattu	Millet thandai
1	Moisture	62.12 ± 1.99	71.58 ± 1.23
2	Ash	0.94 ± 0.10	1.46 ± 0.17
3	Fat	3.74 ± 0.01	5.18 ± 0.06
4	Crude fibre	1.05 ± 0.05	0.52 ± 0.24
5	Crude protein	4.38 ± 1.55	1.07 ± 0.25
6	Carbohydrates	24.63 ± 2.55	20.15 ± 1.32
7	Energy	150 ±16.40	132 ±3.96

All the values are mean ±standard deviation of three observations.



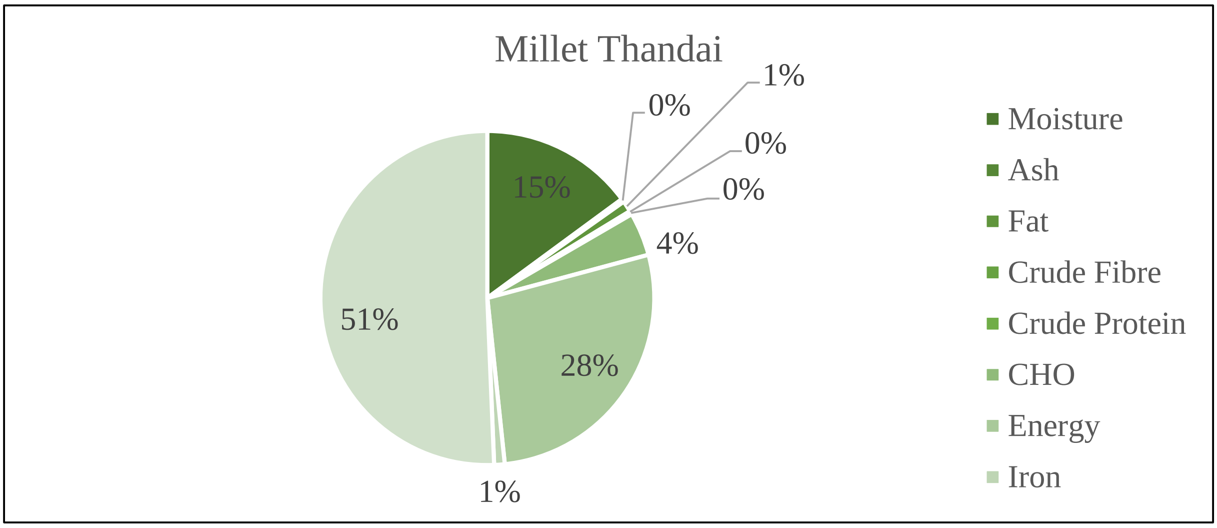


Fig. 4.4: proximate composition of developed beverages

However, Balancing the nutrients in millet-based beverages is crucial for optimizing energy content and health benefits, especially in disease conditions. Panch Millet Sattu, with higher protein and fiber, offers a nutrient-dense option for muscle repair and digestive health. Its lower moisture content also concentrates nutrients, making it ideal for individuals needing higher nutrient intake in smaller servings. Millet Thandai, with higher fat and moisture, provides more energy and hydration, beneficial for patients needing quick energy boosts and fluid intake. Both beverages have balanced carbohydrates, supporting sustained energy without spiking blood sugar levels, making them suitable for various health needs.

10. Mineral estimation:

Table 4.7 and fig. 4.5 illustrates the mineral composition of developed millet based beverages.

a) Iron:

The iron content of both beverages was determined by using the Atomic Absorption Spectrophotometer (AAS) method suggested by 'Bishnoi and Brar (1988). It was found that *Panch Millet Sattu* had an iron content of 2.41 ± 0.03 and in one serving it provided 0.48 mg. According to IFCT (2017), the iron content present in one serving is 0.32 mg. The iron content of *Millet Thandai* was 4.89 ± 0.06, and in one serving it provided 0.96mg. According to IFCT (2017), the iron content present in one serving is 0.58 mg. hence, the results obtained are higher in comparison to IFCT. It is also suggested by Singh *et al*. (2018), that the bioavailability of iron increases with roasting.

b) Calcium:

Calcium content was determined using the titrimetric method (Cheng and Bray, 1951). It was found that *Panch Millet Sattu* had a calcium content of 68.33 ± 0.09 and in one serving it provided 13.66mg calcium. In another side, IFCT (2017), provide calcium from one serving is 12.76 mg. The calcium content of *Millet Thandai* was 243.1 ± 4.13, and in one serving it provided 48.62 mg respectively. In the study by Singh *et al*. (2018), it was suggested that roasting of millets increases the bioavailability of calcium.

Table 4.7: Mineral content of prepared beverages (per 100g)

S.no.	Mineral analysis	Panch millet sattu	Millet thandai
1	Iron (mg)	2.41 ± 0.03	4.89 ± 0.06
2	Calcium (mg)	68.33 ± 0.09	243.1 ± 4.13

All the values are mean ±standard deviation of three observations.

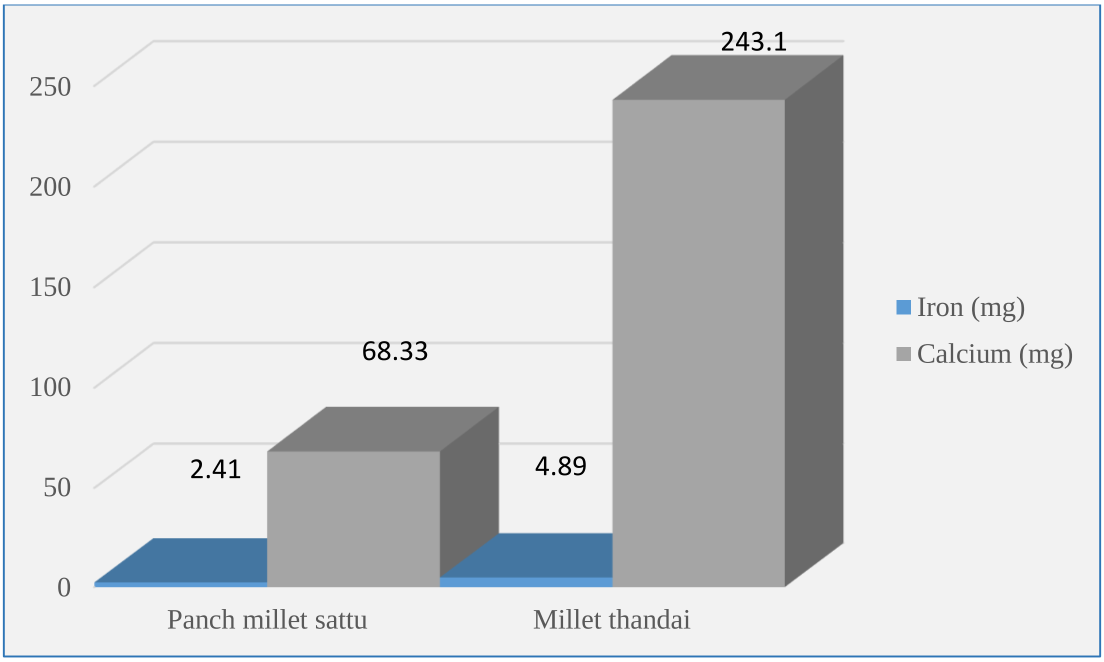


Fig. 4.5: Mineral content of prepared beverages

Nutritional composition of developed millet-based beverages for one serving:

Nutritional composition of beverages for per serving given below in table 4.8.

Serving size: - 2 tablespoons (20g) in 200ml (water for *Panch millet sattu* and milk for *Millet Thandai*)

Table 4.8: Nutritional composition of prepared beverages per serving size

Nutritional composition	*Panch Millet Sattu*	*Millet Thandai*
Energy (kcal)	30	64
Fat (g)	0.68	1.02
Crude fibre (g)	0.2	0.1
Crude protein (g)	0.86	0.2
Carbohydrates (g)	4.92	4.02
Iron (mg)	0.48	0.96
Calcium (mg)	13.66	48.62

4.3 Shelf life estimation of Millet-Based Beverages

Food product quality, preservation, and handling are essential aspects of food that can influence acceptability and shelf life of the food product. Any minor change, external or internal, could lead to a decrease in quality. The shelf life of food products serves to provide information about the time period during which the product can be eaten. To determine a food's expected shelf life, it is crucial to understand microbial, enzymatic, and chemical reactions. Degradation of processed foods can be due to microbial deterioration, chemical and enzymatic activity, colour, flavour, consistency changes, moisture level, water activity, and a poor packaging system. These processes help to understand and maintain food's safety and quality.

This section provides information on the sensory and microbiological profiles of standardized items over the storage period of time. Products were asked to maintain quality for two months. 100 g items were manufactured and put in sterilised glass bottles, then kept at room temperature for two months.

Effect of storage on sensory attributes of the beverages

The organoleptic acceptability of a food product is a combination of different sensory properties such as colour, appearance, texture, flavour, taste, and overall acceptability. A selected group of panellists evaluated the distinct sensory qualities of the both beverages at fifteen-day interval, namely 0, 15, 30, 45, and 60 days, for a period of two months. The sensory ratings given by panel members on the nine-point Hedonic Rating Scale (Rangana, 2002) throughout the storage period were statistically examined using one-way analysis of variance. Tables 4.9 and 4.10 give the results of the sensory examination of beverages. During storage period at ambient temperature, the results are discussed below:

Panch millet sattu

Table 4.9 and Figure 4.6 show the sensory quality of *Panch Millet Satttu* throughout a range of storage durations (0–60 days). There were no significant changes in the sensory qualities of *Panch Millet Sattu* over storage periods. No significant difference was seen in sensory qualities of *Panch Millet Sattu* ($p \geq 0.05$) over 60 days of storage and the sensory scores for all qualities ranged from 7-8 (moderately very much liked) indicating an acceptance of *Panch Millet Sattu* beverage.

Table 4.9: Effect of storage period on sensory qualities of *Panch Millet Sattu*

Day	Colour	Flavour	Taste	Consistency	Appearance	Overall Acceptability
0	8 ± 0.79	7.97 ± 0.81	8.27 ± 0.68	7.9 ± 0.76	7.8 ± 0.92	8.2 ± 0.66
15	7.93 ± 0.74	7.93 ± 0.83	8.23 ± 0.68	7.9 ± 0.76	7.65 ± 1.32	8.1 ± 0.76
30	7.76 ± 1.04	7.73 ± 0.78	8.13 ± 0.68	7.9 ± 0.76	7.60 ± 1.26	8.13 ± 0.63
45	7.63 ± 1.22	7.67 ± 0.88	8 ± 0.95	7.83 ± 0.83	7.76 ± 0.97	7.96 ±0.76
60	7.56 ± 1.17	7.43 ± 0.86	7.97 ± 0.93	7.56 ± 0.97	7.7 ± 0.99	7.83 ± 0.91
S.E.	0.18	0.15	0.14	0.14	0.17	0.13
C.D.	0.36	0.30	0.28	0.29	0.34	0.26

All the values are mean ±standard deviation of three observations. SE- Standard error, Non-significant

Day 0: The *Panch Millet Sattu* began with high scores in every aspect, indicating good initial quality. Freshness was at its best, contributing to the overall acceptance of the beverage. **Day 15**: It was observed that there was a small reduction in colour and appearance scores. Other features were very steady. Overall acceptance decreased somewhat, but remained high. **Day 30**: The colour and taste scores decreased noticeably. Taste and consistency stayed rather constant. Appearance was slightly deteriorated. Despite such changes, the overall acceptability remained substantial.

Day 45: Colour, flavour, and taste scores continued to diminish gradually. Consistency and appearance were reasonably constant. Overall acceptability decreased significantly but remained above 7.9.

Day 60: All qualities gradually declined, with the most noticeable decline in flavour and colour. Consistency and look remained basically consistent, but somewhat diminished. Overall acceptance reflected the total impact of these changes, with a more apparent reduction than earlier periods.

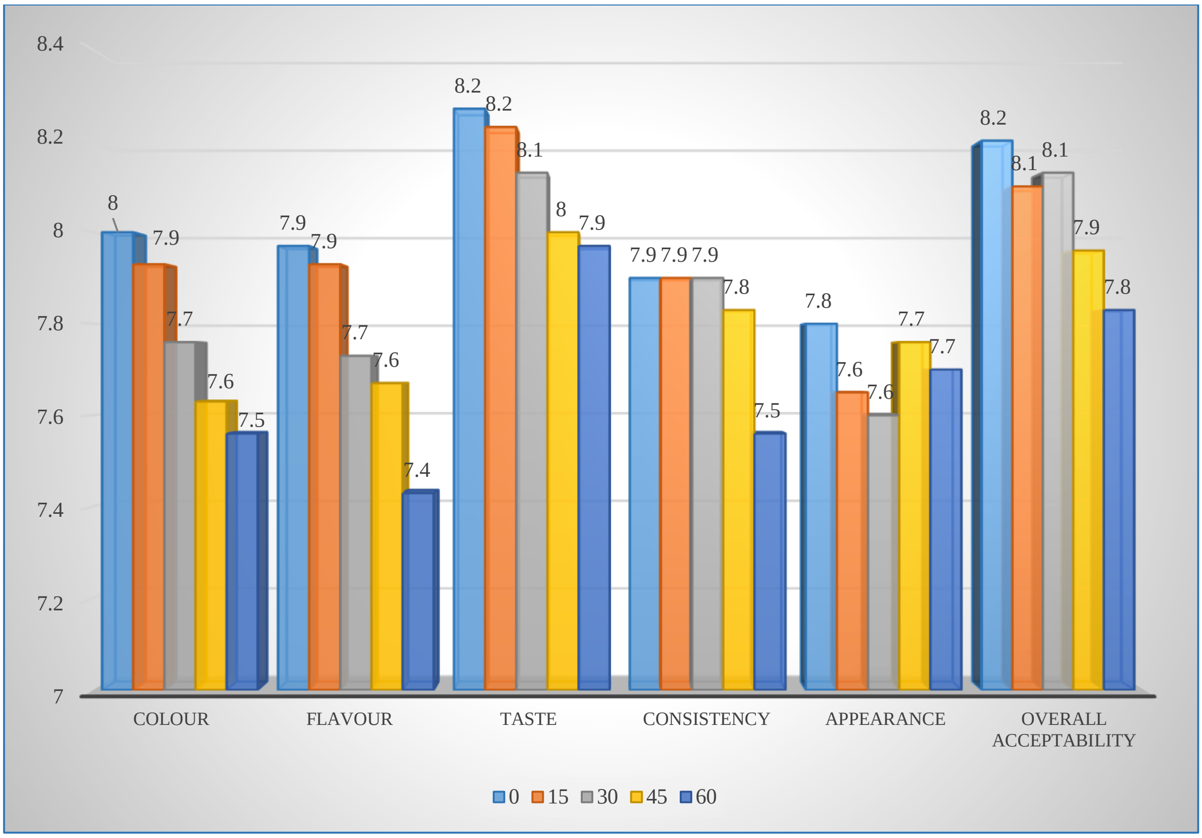


Fig. 4.6: Effect of storage period on sensory qualities of *Panch Millet Sattu*

Millet thandai

Table 4.10 and Figure 4.7 show the sensory evaluation of *Millet Thandai* throughout a range of storage durations (0–60 days). At ambient temperature, except flavour attributes, there was no significant alteration in the sensory qualities of *Millet Thandai* over storage periods. Until the 45th day, sensory scores for all qualities ranged from 7-8 (moderately very much liked). On the 60th day, ratings ranged from 7-8, indicating an acceptable level of "liked moderately to very much."

A significant difference was seen only in flavour attribute of sensory qualities of *Millet Thandai* ($p \leq 0.01$) over 60 days of storage period.

Table 4.10: Effect of storage period on sensory qualities of *Millet Thandai*

Day	Colour	Flavour	Taste	Consistency	Appearance	Overall Acceptability
0	8.23 ± 0.67	8.03 ± 0.61	8.53 ± 0.73	8.2 ± 0.84	8.1 ± 0.80	8.36 ± 0.66
15	8.13 ± 0.73	7.96 ± 0.66	8.5 ± 0.73	7.76 ± 0.81	8.03 ± 8.05	8.33 ± 0.71
30	8.06 ± 0.78	7.76 ± 0.71	7.76 ± 1.33	7.73 ± 0.82	7.86 ±0.86	8.26 ± 0.73
45	8 ± 0.87	7.56 ± 0.67	7.1 ± 1.60	7.56 ± 0.89	7.73 ± 1.01	7.63 ±1.15
60	7.8 ± 1.03	7.43 ± 0.56	7 ± 1.50	7.36 ± 0.96	7.6 ± 0.93	7.53 ± 1.10
S.E.	0.15	2.19	0.21	0.16	0.15	0.16
C.D.	0.29	4.34**	0.42	0.31	0.31	0.31

All the values are mean ±standard deviation of three observations. SE- Standard error, ** Significant at 1% level of significance

Day 0: The drinks began with high ratings in all aspects, suggesting great starting quality and maximum freshness.

Day 15: The colour and appearance decreased a bit, while other features remained fairly consistent. A minor decrease was observed in overall acceptability.

Day 30: Colour and flavour scores decreased greatly, while taste and consistency remained rather stable. Despite changes, overall acceptance remained sturdy.

Day 45: On Day 45, colour, flavour, and taste scores continued to go down. Consistency and appearance remained basically consistent, but overall acceptance fell significantly.

Day 60: All qualities gradually deteriorated, with the most notable decreases in flavour and colour. The consistency and appearance were essentially consistent but somewhat diminished, resulting in a more noticeable reduction in overall acceptability.

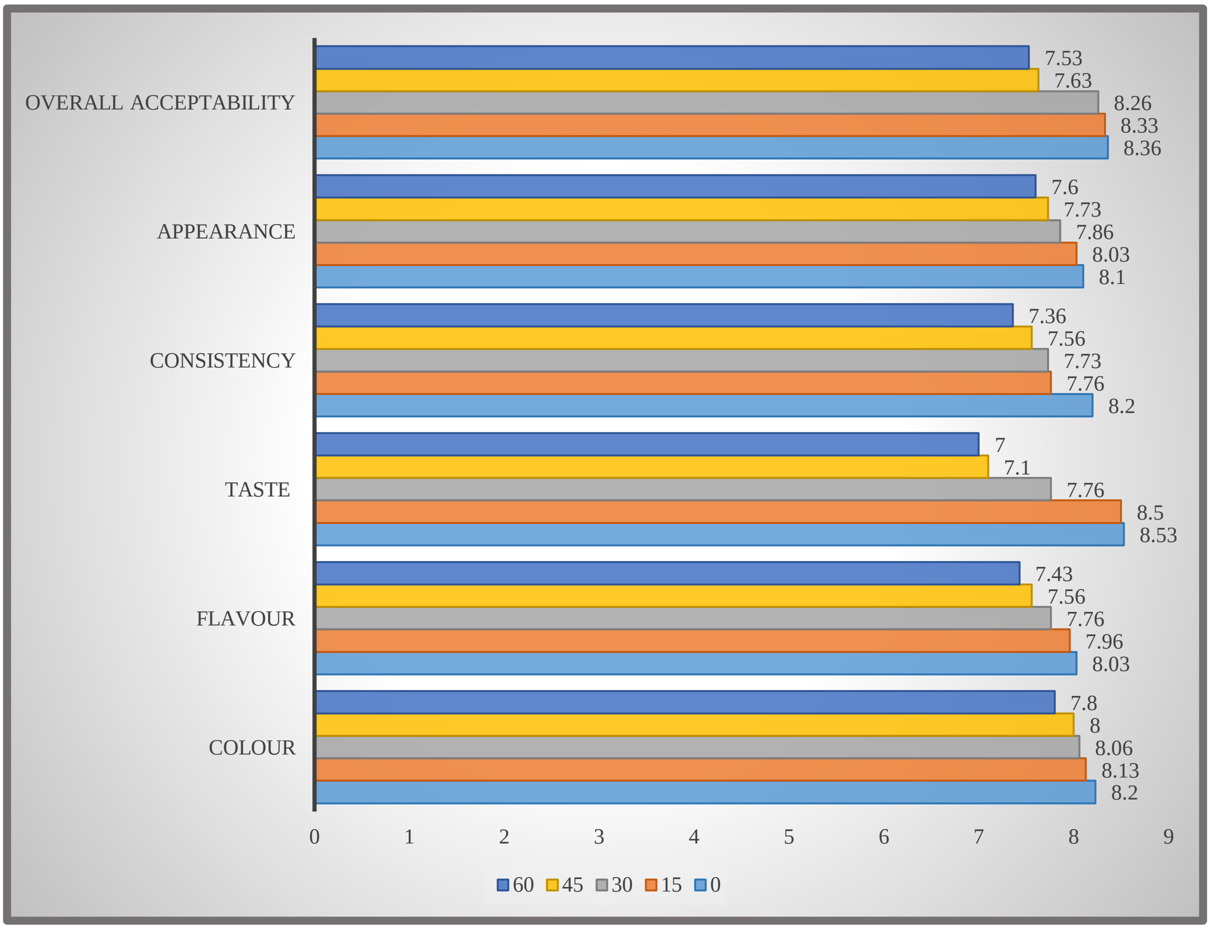


Fig. 4.7: Effect of storage period on sensory qualities of *Millet Thandai*

Product quality may affect at a certain period of storage, millet-based sugar syrup may develop off-flavours and taste changes due to several factors. Chemical degradation, including hydrolysis and oxidation, can break down flavour compounds, leading to undesirable tastes. Oxidative rancidity, even in low-fat syrups, can produce rancid flavours, exacerbated by ambient temperature conditions. Fluctuations in ambient temperature can accelerate flavour compound breakdown, and caramelization or pH changes in the developed millet beverages may further impact taste. Additionally, natural aging processes can alter sensory properties, affecting aroma and flavour.

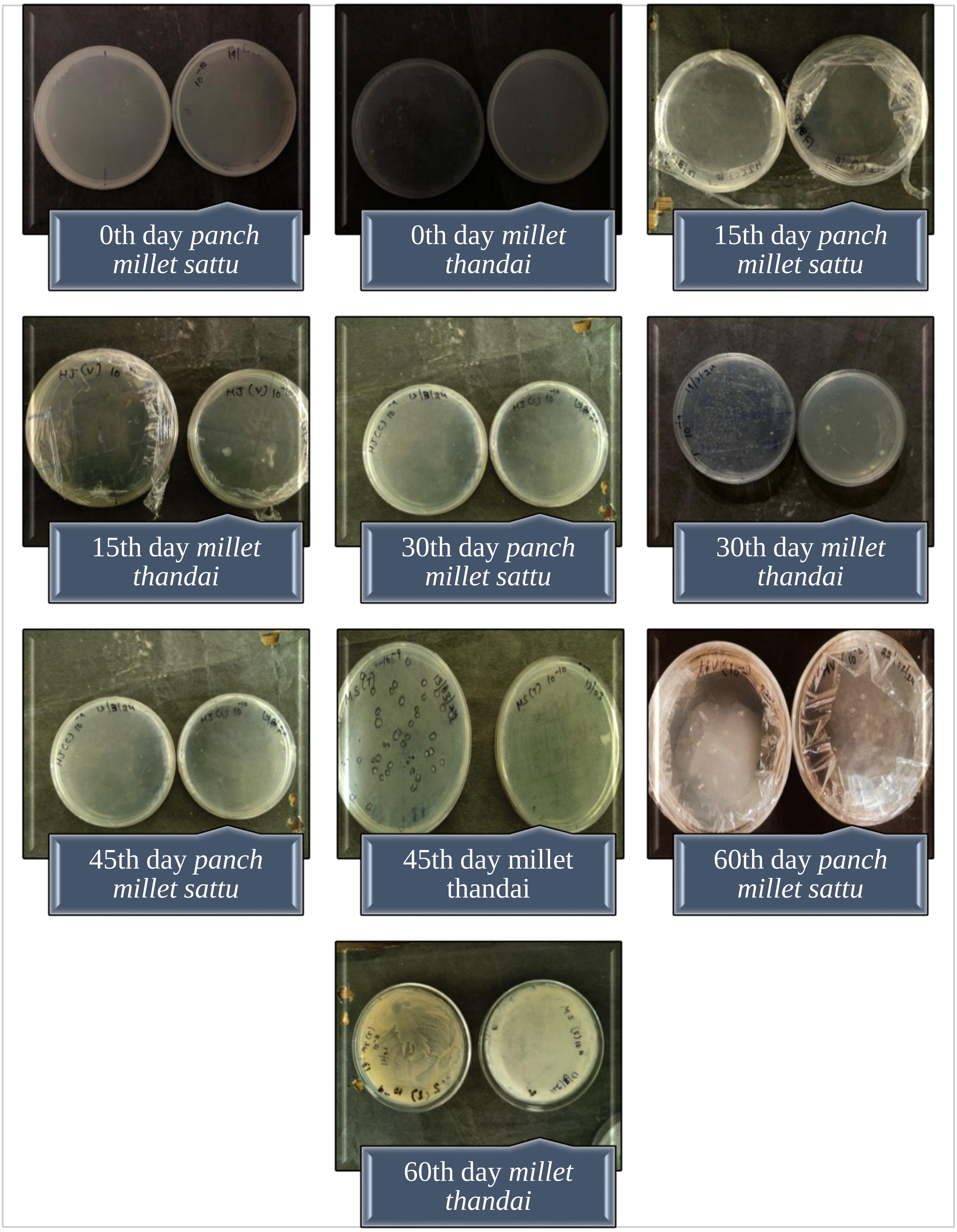


Plate 4.2: Total plate count of developed beverages (*Panch millet sattu* and *Millet Thandai*)

Total plate count in *Panch Millet Sattu*

Plate 4.2 shows the colony count of microorganisms over 60 days, measured in 10^{-9} and10^{-10} dilutions. The presence and growth of colonies indicate microbial activity, which could affect product safety and stability.

On the 0^{th} and 15^{th} day, no colonies were identified. It indicates a sterile and low-microbial environment. After Day 30, there was a significant rise observed in microbial colonies, particularly in the 10^{-9} dilution, indicating long-term microbial development. On Day 60^{th} day, the microbial population had grown significantly, with estimates ranging from more than 170 colonies in 10^{-9} and more than 140 colonies in 10^{-10} dilution. This suggests that microbial multiplication may be rapid over the course of 60 days.

Table 4.11: Microbial colonies present in *Panch Millet Sattu*

Days	**Cfu/ml in 10^{-9} dilutions**	**Cfu/ml in 10^{-10} dilutions**
0^{th}	Nil	Nil
15^{th}	Nil	Nil
30^{th}	6 $x10^{-9}$	Nil
45^{th}	48 $x10^{-9}$	53 $x10^{-10}$
60^{th}	>160 $x10^{-9}$	>140 $x10^{-10}$

Microbial standards for milk and milk products (FSSAI): total aerobic count or total plate count of pasteurised or boiled milk and flavoured milk; the count is 5 x 10^4 per ml. Hence, the *Panch Millet Sattu* beverage is meeting the guidelines as per FSSAI for milk and milk products as it has microbiological counts below than 5×10^4 cfu/ml.

Total plate count in *Millet Thandai*

The table 4.12 highlight the fast growth of microbial colonies during a 60-day period, measured at dilutions of 10^{-9} and 10^{-10}. Initially, neither dilution exhibited any microbial activity, indicating a sterile starting point. By Day 15, microbial growth was minimal, with 8 colonies in the 10^{-9} dilution and 3 colonies in the 10^{-10} dilution. The condition continued, reaching 38 colonies (10^{-9}) and 28 colonies (10^{-10}) on 30^{th} day, and then rising to 165 colonies (10^{-9}) and 180 colonies (10^{-10}) on 45^{th} day. The microbial population the end of day 60, grow more than 200colonies (10^{-9}) to more than 250 colonies (10^{-10}). These findings emphasise the fast expansion of microbial colonies over the storage period.

Table 4.12: Microbial colonies present in *Millet Thandai*

Days	**Colonies in 10^{-9} dilutions**	**Colonies in 10^{-10} dilutions**
0^{th}	Nil	Nil
15^{th}	$8\ x10^{-9}$	$3\ x10^{-10}$
30^{th}	$38\ x10^{-9}$	$28\ x10^{-10}$
45^{th}	$165\ x10^{-9}$	$180\ x10^{-10}$
60^{th}	$>200\ x10^{-9}$	$>250\ x10^{-10}$

According to FSSAI, the microbial standards for milk and milk products for the total aerobic count or total plate count of pasteurised, boiled, and flavoured milk; the count is 5×10^4 cfu/ml. The prepared *Millet Thandai* have microbiological counts below 5×10^4 cfu/ml Hence, *Millet Thandai* fulfilling FSSAI specifications for microbial counts.

SUMMARY AND CONCLUSION

Farmers primarily grow millets as a group of small-seeded perennial grasses; these crops are generally cultivated on marginal land in dry areas. 59 million people in Asia and Africa considered millets a staple diet due to their rich source of nutrients. They have the capability to lower the chance of acquiring cardiovascular problems, which helps in weight reduction. They contain B complex vitamins such as niacin, folacin, riboflavin, thiamine, and phosphorus. Millets have regained popularity recently due to their advantages in terms of health, lower environmental impacts, and climate change resistance. However, they are often disregarded and underappreciated in contemporary diets and agricultural practices.

Millets are divided into two categories: minor and major, which differ in grain size and growth areas. Pseudo millets are millets that are not in the *Poaceae* family but are similar to major and minor millets. Foxtail millet, little millet, and kodo millet are all examples of minor millets. Kodo millet is the coarsest grain, has a large amount of lecithin, and is beneficial for boosting immunity. Major millets include pearl millet, sorghum, finger millet, foxtail millet, tiny millet, and kodo millet. Pearl millet has the highest macronutrient content of any other millet, it has the highest concentration of resistant starch and soluble and insoluble dietary fibres. On the other hand, sorghum is high in minerals and B complex vitamins and is also an important tropical cereal crop for food, feed, and fodder in semiarid areas. Finger millet is the richest source of amino acids, high in sulphur and calcium, and has powerful antioxidant effects.

According to Niti Ayog (2023), millets are slowly coming back to the diet as a healthy superfood. The year 2023 is being celebrated as the International Year of Millets (IYM), which provides a unique opportunity to engage all stakeholders to promote the production, productivity, and consumption of millets. Gowri (2020) reviewed statistical data in his study and found that in India, millets experienced negative growth rates of 16.31 percent and 13.58 percent per year from 1950 to 2005 but showed positive growth 3.23 percent after 2005. From 1961 to 2018, global millet cultivation declined by 25.71 percent, but productivity increased by 36 percent, with India being the largest producer and West Africa showing the highest production growth (Meena *et al.*, 2021).

Millet-based beverages are gaining popularity due to the growing demand for nutritional and functional drinks among people who are health-conscious. Hence, it was decided to develop non-fermented beverages by incorporating millets into some traditional summer drinks for nutritional enrichment.

The present study was aimed to develop and standardize millet-based non-fermented beverages, as well as to assess their nutritional quality and shelf life of the prepared millet-based non-fermented beverages. The study was conducted in these phases: procurement, development and standardisation and nutritional and shelf life assessment.

In the first phase, millets were procured from local market. Millets (pearl millet, foxtail millet, sorghum millet, ragi and barley) were bought in a single lot from the local mandi. The other raw ingredients that were used to prepare beverages were also procured from local market of Udaipur city. The beverages with incorporation of millets like pearl millet, foxtail millet, sorghum millet, ragi and barley were used in developing for *Panch Millet Sattu* and for *Millet Thandai*, ragi and foxtail millet were selected and were standardised to offer healthy drinks to people of different age groups, like children, adolescent, adults and older ones. The acceptability and serving of the beverages was judge using 9 point hedonic rating scale (Ranganna, 2002), by a panel of trained judges. The acceptability scores of *Panch Millet Sattu* was ranged from 7.1 to 8.2 and *Millet Thandai* was 7.3 to 8.3 respectively. *Panch Millet Sattu* (S2) and *Millet Thandai* (T2) was liked very much from all the treatments. Therefore, the selected beverages of both (S2 and T2) were then analysed for the further study. The cooked weight of *panch millet sattu* was 274.8 g and *millet thandai* was 256.43g. The cooked time for both beverages was approx. 30 minutes.

The beverages were then analysed for the physico-chemical and nutritional analysis using standard methods. The physico-chemical estimation included Total Soluble Solids (TSS), pH of *Panch Millet Sattu* and *Millet Thandai* was 70° Brix and 71° Brix. The proximate composition included moisture, ash, energy, protein, fat, fibre and carbohydrates of *Panch Millet Sattu* was 62.12 g, 0.94 g, 150 kcal, 4.38 g, 3.74 g, 1.05g and 24.63g respectively. Whereas, in *Millet Thandai* it was 71.58g, 1.46g, 132kcal, 1.07g, 5.18g, 0.52g and 20.15g respectively. The mineral estimation included iron and calcium. The iron content of both beverages (*panch millet sattu* and *millet thandai*) was 2.41mg and 4.89mg respectively, and calcium content of both beverages (*panch millet sattu* and *millet thandai*) was 68.33mg and 243.1mg.

The beverages were then analysed for their shelf life of 60 days at ambient temperature. During storage period, the sensory qualities were gradually declined, the decline in the overall acceptability was observed in *panch millet sattu*, the mean value recorded was 7.83 ± 0.91 and in *millet thandai* was 7.53 ± 1.10 respectively. Yet the scores are more than 7.0 which describes liked moderately, hence we can say that millet-beverages can be stored for a 60-day period at ambient temperature.

The microbial count was observed in both beverages by Total Plate Count (TPC), it was observed that microbial colonies were absent in the beginning but grew significantly after 60 days in *panch millet sattu* was >160 $x10^{-9}$ and >140 $x10^{-10}$, showing fast microbial multiplication in the long run. And in *millet thandai* it was >200 $x10^{-9}$ and >250 $x10^{-10}$ respectively. Microbial standards for milk and milk products (FSSAI): total aerobic count or total plate count of pasteurised or boiled milk and flavoured milk; the count is 5×10^4 cfu/ ml.

From the above results it can be concluded that millets have good nutritional content and on roasting they liberate aroma and flavour that enhances the developed product acceptability. As in results, both the beverages were well accepted and had good nutritional composition. Millets (pearl millet, foxtail millet, sorghum millet, ragi and barley) incorporated to develop *panch millet sattu* and millets (ragi and foxtail) incorporated to develop *millet thandai* showed high levels of iron and calcium and as well as in protein content. It can also be said that by incorporating millets in beverages more than a given range can affect the consistency of the beverages but can enhance their sensory qualities.

Recommendations:

1. More millet-based, non-fermented beverages can be made to promote health and millet production.
2. Millet incorporation can be increased in new products to make them acceptable both nutritionally and orgenoleptically.
3. To promote millet consumption, the market potential for processed millet items such as millet cookies and ready-to-eat extruded snacks, as well as millet-based drinks, must be deliberately expanded.
4. Because millets have good nutritional content and also have a better possibility of economic success, novel products derived from them should be developed and standardised.
5. It should be included to the diet to prevent nutrient deficiencies such as calcium, iron, and protein.

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M.SC. RESEARCH-2024

Title: "Development and Standardization of Millet-Based Non- Fermented Beverages"

ABSTRACT

Millets, small-seeded perennial grasses, are a staple diet for 59 million people in Asia and Africa due to their rich nutritional content and potential to reduce cardiovascular problems. They contain B-complex vitamins like niacin, folacin, riboflavin, thiamine, and phosphorus. However, millets are often disregarded in contemporary diets and agricultural practices due to a lack of production and availability. To address this, the present study was aimed to develop and standardize millet-based non-fermented beverages by keeping the objectives in mind: to develop and standardise millet-based non-fermented beverages, to analyse the physico-chemical analysis and nutritional composition of the developed millet-based non-fermented beverages, and to estimate the shelf life of the developed millet-based beverages. The beverages were standardised to provide a good amount of calcium per serving size. Both *panch millet sattu* and *millet thandai* development include the roasting process of millets. For acceptability for both beverages, a 9-point hedonic rating scale was used.

The overall acceptability score for *panch millet sattu* and *millet thandai* was 7.1–8.2 and 7.3–8.3, respectively. The most acceptable beverages, *Panch Millet Sattu* (S2) and *Millet Thandai* (T2), were subjected to nutritional analysis for physico-chemical and nutritional analysis, which included pH, TSS, proximate composition (moisture, ash, crude fat, crude fibre, protein, carbohydrates, and energy), and mineral estimation (iron and calcium) by using standard methods. The TSS and pH of *panch millet sattu* and *millet thandai* were 70 ºBrix and 71.1 ºBrix; 4.36 and 8.38 pH. The proximate composition of *panch millet sattu* was 62.12 g, 0.94 g, 3.74 g, 1.05 g, 4.38 g, 24.63 g, and 150 kcal per 100 g. And in *millet thandai*, it was 71.58 g, 1.46 g, 5.18 g, 0.52 g, 1.07 g, 20.15 g, and 132 kcal per 100 g. The mineral content present in both beverages was: the iron content of *panch millet sattu* and *millet thandai* was

2.41 mg and 4.89 mg, and the calcium content of *panch millet sattu* and *millet thandai* was 68.33 mg and 248.1 mg per 100 g.

The shelf life of both beverages was assessed during the storage period at ambient temperature for 60 days. A very significant change was observed in the sensory qualities of both beverages, but significant growth of microbial colonies was observed until the 60th day of the storage period in both beverages. Hence, it can be said that upon refrigerating these beverages, an increase in shelf life can be observed.

Keywords: Millet, Millet beverage, Roasting, Traditional millet drinks, Nutritional benefits, Shelf life

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महाराणा प्रताप कृषि एवं प्रौद्योगिकी विश्वविद्यालय

सामुदायिक एवं व्यवहारिक विज्ञान महाविद्यालय, उदयपुर

खाद्य विज्ञान एवं पोषण विभाग

स्नातकोत्तर शोध कार्य- 2024

शीर्षक: "मिलेट आधारित अ-किण्डवित पेय पदार्थों का विकास एवं मानकीकरण"

अनुक्षेपण

मिलेट्स, छोटे बीज वाले बारहमासी घास हैं तथा एशिया और अफ्रीका के 59 मिलियन लोगों के लिए एक मुख्य आहार हैं, जो उनके समृद्ध पोषण का स्तोत्र और हृदय रोगों को कम करने की क्षमता रखते हैं। इनमें बी-कॉम्प्लेक्स विटामिन्स जैसे नायसिन, फोलासिन, राइबोफ्लेविन, थायमिन और फॉस्फोरस होते हैं। हालाँकि, मिलेट्स को अक्सर उत्पादन और उपलब्धता की कमी के कारण समकालीन आहार और कृषि प्रथाओं में नजरअंदाज कर दिया जाता है। इसे ध्यान में रखते हुए, वर्तमान अध्ययन का उद्देश्य मिलेट-आधारित अ-किण्डवित पेय पदार्थों को विकसित करना और मानकीकरण करना था। ये पेय पदार्थ किसी भी आयु वर्ग जैसे बच्चे, किशोर, वयस्क और बुजुर्गों द्वारा सेवन किए जा सकते हैं ।

अध्ययन, इन उद्देश्यों को ध्यान में रखते हुए किया गया, जिनके उद्देश्य कुछ इस प्रकार थे: मिलेट-आधारित अ-किण्डवित पेय पदार्थों का विकसित करना और मानकीकरण करना, विकसित मिलेट-आधारित अ-किण्डवित पेय पदार्थों का भौतिक-रासायनिक विश्लेषण और पोषण संरचना का विश्लेषण करना, और विकसित मिलेट-आधारित पेय पदार्थों के अचल जीवनकाल का अनुमान लगाना। पेयों पदार्थों को प्रति सेवारत मात्रा में अच्छी मात्रा में कैल्शियम प्रदान करने के लिए मानकीकृत किया गया था। दोनों पंच मिलेट सत्तू और मिलेट ठंडाई के विकास में मिलेट्स को भुनने की प्रक्रिया शामिल थी। दोनों पेय पदार्थों की स्वीकृति के लिए 9-पॉइंट हेडोनिक रेटिंग स्केल का उपयोग किया गया था। पंच मिलेट सत्तू और मिलेट ठंडाई की समग्र स्वीकृति स्कोर क्रमशः 7.1-8.2 और 7.3-8.3 थे। सबसे स्वीकृत पेय पदार्थ, पंच मिलेट सत्तू (S 2) और मिलट ठंडाई (T 2), को भौतिक—रसायनिक और पोषण विश्लेषण के लिए विषय किया गया, जिसमे pH, TSS, निकतम संरचना (नमी, राख, क्रूड फैट, क्रूड रेशे, प्रोटीन, कार्बोहाइड्रेट्स और ऊर्जा), खनिज पदार्थ (लौह एवं कैल्शियम) शामिल थे। पंच मिलेट सत्तू और मिलट

ठंडाई के TSS और pH: क्रमश: 70° Brix और 71.1° Brix; 4.36 और 8.38 pH थे। पंच मिलेट सत्तू की निकटतम संरचना 62.12 ग्राम, 0.94 ग्राम, 3.74 ग्राम, 1.05 ग्राम, 4.38 ग्राम, 24.63 ग्राम, और 150 किलो कैलोरी प्रति 100 ग्राम थी, और मिलेट ठंडाई में यह 71.58 ग्राम, 1.46 ग्राम, 5.18 ग्राम, 0.52 ग्राम, 1.07 ग्राम, 20.15 ग्राम, और 132 किलो कैलोरी प्रति 100 ग्राम थी। दोनों पेयों की खनिज सामग्री: पंच मिलेट सत्तू और मिलेट ठंडाई का लौह क्रमशः 2.41 मिग्रा और 4.89 मिग्रा, और पंच मिलेट सत्तू और मिलेट ठंडाई का कैल्शियम क्रमशः 68.33 मिग्रा और 248.1 मिग्रा प्रति 100 ग्राम था। दोनों पेय पदार्थों की अचल जीवनकाल का मूल्यांकन 60 दिनों के भंडारण अवधि के दौरान परिवेश तापमान पर किया गया था। दोनों पेय पदार्थों में म्यूक्रोबियल कालोनियों में बहुत कम परिवर्तन देखा गया, ऐसा कहा जा सकता है कि दोनों पेय पदार्थ भंडारण अवधि के दौरान भी उपयोग में लिए जा सकते हैं।

शब्दकुंजी: मिलेट, मिलेट युक्त पेय, भूनना, पारंपरिक मिलेट पेय, पोषण के लाभ, अचल जीवनकाल

डॉ निकिता वधावन
प्रमुख सलाहकार

मोक्षिका सोनी
शोधार्थी

APPENDIX- I

Score card for sensory evaluation of beverages

Date –

Name of Recipe -

Name of Respondent -

Designation –

Please rate the sample for quality attributes according to 9 point hedonic rating scale given below:

S.No.	Quality Description	Score
1.	Like Extremely	9
2.	Like Very much	8
3.	Like Moderately	7
4.	Like Slightly	6
5.	Neither Like nor Dislike	5
6.	Dislike Slightly	4
7.	Dislike Moderately	3
8.	Dislike Very much	2
9.	Dislike Extremely	1

Product Name	Sample No.	Colour	Flavour	Taste	Consistency	Appearance	Overall Acceptability
	1						
	2						
	3						

Remarks, if any; 1.

2. Signature