REVIEW ON NUTRITIONAL AND FUNCTIONAL BENEFITS OF REPLACING REFINED WHEAT FLOUR WITH MILLET FLOUR IN BAKERY PRODUCTS

ABSTRACT

The replacement of refined wheat flour with millet flour in bakery products has gained significant attention due to the potential nutritional and functional benefits. This review aims to evaluate the comprehensive impact of millet flour substitution on the quality, nutritional profile, and consumer acceptability of bakery products. Millet flours, including finger millet, pearl millet, and foxtail millet, kodo millet, sorghum millet, barnyard millet, little millet, proso millet are rich in dietary fiber, essential minerals, vitamins, and antioxidants, offering superior nutritional and dietary benefits compared to refined wheat flour. The functional properties of millet flour, such as water absorption, dough rheology, and baking performance, are critically examined to understand their influence on the texture, flavor, and shelf-life of bakery products. Additionally, the potential health benefits associated with millet consumption, including improved glycemic control and reduced risk of chronic diseases, are discussed. The review also addresses consumer perceptions and acceptance of millet-based bakery products, highlighting sensory evaluations and market trends. Technological challenges and solutions for incorporating millet flour into bakery products are explored, providing insights into processing techniques and formulation adjustments. Furthermore, the economic and environmental implications of transitioning to millet flour are assessed, emphasizing sustainable agriculture and food security. This comprehensive evaluation underscores the promise of millet flour as a viable alternative to refined wheat flour in enhancing the nutritional and functional quality of bakery products.

Keywords: Millet, Nutrition, Glycaemic, Rheology, Texture, Economy.

INTRODUCTION

the population of the world will increase to the thousand crores by the 2050 so as well the demand of food supplies will also be doubled at that time so to fulfil the food necessity, the sustainable agriculture practices will be promoted to sustain and support the global population and millets are the one of most sustainable crops which help to fulfil the demand of necessity due to because their ability to grow in different climate and soils **Chapke *et al.*, (2018).**

The Global food diversity has dwindled significantly, with wheat, rice, and maize dominating approximately 89% of total cereal production worldwide, In response to this concerning trend, the United Nations, in collaboration with India's recommendations, designated 2023 as the International Year for Millets. This initiative aims to revitalize millets and raise awareness about their environmental and nutritional advantages **Naik, (2024).**

Millets are often referred to as smart food (www.smartfood.org), which is "good for the individual" (nutritious and healthy), "good for the planet" (environmentally sustainable), and "good for the farmer" (resilient). Millets are recognized for their resilience, ability to survive under high temperatures and in degraded soils, and minimum requirements of water, pesticides, and fertilizers **Saleh *et al.*, (2013).**

India is the top most producers of millets followed by Nigeria for the year 2000 and 2009. In India, eight millets species (Sorghum, Pearl millet, Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet and little millet) are commonly cultivated under rain fed conditions **Rathod, & Rathod., (2023).** Further, in each of the millet growing areas at least 4 to 5 species are cultivated either as primary or allied crop in combination with the pulses, oilseeds, spices and condiments **Vahini, and Bhaskarachary., (2013).** For instance, while pearl millet and sorghum are primary crop and allied crops respectively in the desert regions of Rajasthan, in the eastern parts of Rajasthan and Gujarat it is the opposite. Similarly, sorghum is sown as major crop in the Telangana, Andhra Pradesh, Maharashtra and parts of Central India, while it is considered as fodder crop in some of the Southern regions. Likewise, Finger millet is a primary crop in Tamil Nadu and Gujarat, while the same is a minor crop in Telangana. **Dayakar *et al.*, (2017)**

Utilization of millets crops is mainly as food for human consumption in the Form of rice, dumpling, porridge, unleavened bread and snacks. In spite of superior value of millets, their use is largely confined to rural areas and very little finds its way to urban markets **Mounika, & Sireesha., (2021).** Bread is traditionally made from wheat flour. Other cereal flours like rye, barley, sorghum

and maize have been used either alone or in combination with wheat flour for bread making in various parts of the world**. (kamaraddi *et al.,* 2003).**

Mehder *et al.,* (2013) found that present trend in population growth indicates that the wheat gap may continue to increase in the future unless well-planned measures are taken to tackle the situation through replaced other wheat cereal in bakery production. On the other hand, celiac disease is a well-known status in numerous countries and represented highly significant population detected. Therefore, the current paper aims to utilize sorghum, in addition to estimate other treatments, fermentation process, gum addition (either 0.5 or 1.0%) only individually or combined together in production of pizza instead of wheat flour. It was undertaken (1) to determine the nutrient contents of the tested sorghum (2) to estimate the chemical and mineral constituents of the resulted pizza and (3) to compare the quality characteristics (antinutritional and sensory properties of the prepared pizza). It was concluded that all the tested treatments organoleptically and nutritionally developed the tested products and produced pizza superior in terms of protein, fiber, ash and mineral contents. This will help in improving status of sorghum among cereals in economics of implementation producers and will contribute for the health of the population.

Durga *et al.,* (2014). conducted a study in which millet-based complementary foods were developed using a combination of sorghum (Sorghum vulgare), rice (Oryza sativa), besan (Cicer arietinum; Bengal gram flour), a legume mix (green gram and roasted Bengal gram; Phaseolus aureus Roxb and Cicer arietinum), and soybean (Glycine max Merr), utilizing a lab-scale twin-screw extruder. The extrudates underwent acceptability testing both initially and after three months of storage at the laboratory level, with a panel of judges evaluating them using a 5-point hedonic scale. Various physicochemical characteristics such as bulk density, piece density, and expansion ratio were measured, and the proximate composition was analyzed. The developed mixes were prepared as porridge and fed to infants, with mothers providing feedback on their acceptability. The complementary mixes containing malted ragi were found to have reduced viscosity, formed a smooth, consistent slurry, and were well received by both the children and their mothers.

NUTRITIONAL PROFILE

Millets contain about 65–75% carbohydrates, 7–12% proteins, 2–5% fat, and 8–15% fiber. They have a higher content of essential amino acids compared to conventional cereals and prolamin in millets increases the digestibility of proteins. While the nutritional advantages of millets have been realized through knowledge sharing in recent times, the therapeutic value of millets needs attention. There is robust scientific evidence to suggest that consumption of millets reduces the progression of prediabetes, results in better glycemic control, reduces body mass index (BMI), and mitigates atherosclerotic cardiovascular disease risk. **Geetha *et al.*, (2022)**

All varieties of millets are abundant in phytochemicals known as polyphenols which have strong antioxidant properties. This antioxidant property helps to flush out harmful free radicals from the body and prevent several helps to flush out harmful free radicals from the body and prevent several potentially fatal conditions ranging from heart diseases to cancer. They also help in reducing inflammation and boost up immunity. Pearl and finger millets are packed with phenol acid 1478mcg and 612 mcg respectively. **kam *et al.*, (2016)**

Studies also indicate that consuming magnesium in daily diet reduce the chances of developing diabetes. Animal studies shows that proso and finger millet can even improve the levels of high-density lipoproteins (HDL) or good cholesterol**. Amadou *et al.*, (2013).**

In research conducted by **Lee *et al.*, 2010)** it was concluded that the pizza base prepared using the millets under the FSSAI limit have given an exceptional improvement in the nutritional profile which include the increase in the protein percentage and fiber percentage in compare to the refined wheat flour-based pizza base. **Singh, & Lal, (2024).** in their research it was also concluded that the fat and moisture in the prepared pizza base was lower in comparison to the pizza base which was prepared using refined wheat flour which are solely popularized in the market, when we talk about the microbial activity, it was also under control they concluded that the microbial growth or total plate count was under control till the fourteenth day when it was stored at the normal room temperature of 26±2 ^{O}C by the fifteenth day it crossed the limit of microbial growth which were set by the FSSAI for the bakery products.

Malnutrition is defined as the deficiency, excess or imbalance in the intake of energy and/or nutrients. The term malnutrition addresses 3 broad groups of conditions, Undernutrition, Micronutrient-related malnutrition and Overweight. millets are highly nutritious due to the presence of carbohydrates, proteins, dietary fibres, vitamins like niacin, riboflavin and minerals like calcium, iron and phosphorus. Some millets are also rich in antioxidants and phenolic

compounds like vanillic acid, gallic acid, tannins, ferulic acid etc. In 2017 a review conducted by **Ayerza *et al.*, (2017)** stating that millets may help manage micronutrient-related malnutrition. Thus, the consumption of millets may positively impact malnutrition. Though scientific evidence to support these claims is limited, we need more studies to ascertain these claims with better results. in research conducted by **Tripathi *et al.*, (2023**) after the proximate analysis of different different millet including pearl millet, finger millet, foxtail millet and others majors millet cultivated in India, it was stated that the millets are highly rich in the protein content and fiber content, the protein content ranges between the 6 to 15 percentage and the fiber content ranges between the 2 to 15 percentage the elaborated data is mentioned in the table 1 below

Table 1. representing the prtein and fiber content in millets

Millet Type	**Protein (%)**	**Dietary Fiber (%)**
Pearl millet	8 -18	2 - 3
Finger millet	7.7 – 12.3	3.6 – 5.8
Foxtail millet	8 -12	5 - 8
Proso millet	10 - 15	1.2 - 12
Little millet	7 - 12	6 - 9
Kodo millet	8 - 11	8 - 9
Barnyard millet	6 - 11	11 - 15

Source:(Longvah *et al.*, 2020)

A study conducted by the **Jacob *et al.*, (2024)** analysed that the millet has better nutritional profile of vitamins and minerals according to their data calcium present in the finger millet were 344 mg which was the highest among all the others millet available or cultivated in our Indian sub-region similarly the barnyard millet among all millet has better composition of the iron content which is near about 15 mg as it was mentioned in the table 2 below.

Table 2. Vitamins and Mineral content and of millets

Nutrient	Finger Millet	Foxtail Millet	Pearl Millet	Barnyard Millet	Kodo Millet	Little Millet	Proso Millet
Calcium (mg)	344	31	42	20	27	17	14
Iron (mg)	3.9	1.1	2.8	15	0.6	9.3	3.8
Zinc (mg)	2.8	1.1	1.7	0.4	1.2	1.2	1.7
Phosphorus (mg)	283	258	285	293	189	207	277

Source: Nutritive value of Indian foods, Millet Network of India, 2009.

CONSUMER ACCEPTABILITY TOWARDS MILLET BASED PRODUCT

in a rerearch perfoformed by **Soumya and Mamatha (2020)** it was stated that the consumer acceptability of the millet-based biscuit among all the parameters, like Nutrition, Freshness, Taste, Variety, Consistency, Convenience, Ingredient majority (more than 90%) of the consumers accepted little millet-based biscuits. The lesser percentage of consumer preference level was recorded for taste and appropriate packaging. This may be due to the accustomed habit of consuming refined wheat flour-based bakery products for a long time.

A Research conducted by **Bakshi*, et al.*, (2023)** aimed to examine the impact of millet-based fast-food attributes on creating memorable food experiences for students and to evaluate their acceptability of these food items. Two null hypotheses were tested, and the results offered valuable insights. The first hypothesis (H_{01}) explored how millet-based fast-food attributes influence memorable food experiences. The analysis revealed a significant relationship between the attributes of these food items and students' memorable food experiences. Key attributes such as taste, ingredient combination, convenience, healthiness, and menu variety were found to positively impact these experiences, suggesting that millet-based fast food contributes to creating memorable culinary moments for students. The second hypothesis (H_{02}) assessed the acceptability of millet-based fast-food items, based on students' food experiences. The findings showed a strong correlation between the attributes of these items and their acceptability among students. All 15 attributes had a positive influence on acceptability, with taste, ingredient combination, value for money, and ease of digestion being particularly important. This indicates that millet-based fast food is not only acceptable but also preferred by students.

HEALTH ASPECTS OF MILLETS

As per data in Charaka Samhita, a prominent treatise of *Ayurveda*, millets are said to be *kashaya* (astringent) and *madhura* (sweet) in taste, light in digestion, aggravating *vāta*, and pacifying *kapha* and *pitta*. Many Nighantus (encyclopaedic lexicons) in *Ayurveda* have referred to millets as sweet and astringent in taste but pungent in effect after digestion. The yellow variety of foxtail millet is described as the best among millets in the *Ayurvedic* writings. It is also considered good for the fracture healing and stoutening of the human body ***e-vagbhata., (2023).*** Repeatedly, *kodrava* (kodo millet) is mentioned as *visahara* (alleviating poison) by Kaiyadeva Nighantu and Dhanvantari Nighantu. Millets also advised to be good for healing ulcers. However, the excessive consumption of *kodrava* whose common name is (kodo millet) and *uddalaka (vanakodrava*, wild Kodo millet*)* is said to cause *raktapitta* (bleeding disorders) as mentioned in the **garuda purana.** ***4th ed. Delhi.***

Abd *et al.*, 2012 in his study stated that millet helps in maintaining probiotic and prebiotic balance in the human body. probiotics helps in maintaining the useful bacteria in colon which get reduced in human body due to the diseases. natural probiotics are prepared by fermenting the millets which is helpful in curing the diarrhoea in childrens. **Lei *et al.*, (2006)**

Prebiotics were non-digestible food ingredients that selectively stimulated the growth and activity of specific bacteria in the colon, thereby benefiting the host. Grains of millets also exhibited prebiotic activity, which helped increase the population of beneficial bacteria crucial for improving digestion. Malting induced significant biochemical changes in the millet grain, enhancing its beneficial properties. **Anjali *et al.*, (2021).**

Singh *et al.*, 2023 in their study stated that the millets are exceptionally low in the glycemic index and high in fiber content and presence of the phytochemical makes it the perfect food for the maintaining the blood glucose level, or insulin spikes for the diabetic patient.

CHALLENGES IN INCORPORATING MILLET

millets are seen as superior alternative when it comes to replace the wheat flour from the bakery products but the millets have some limitations that it faces issue while the sensory of the product people have acquired the taste of wheat so much that they refuse to accept the taste of other grains also millets exhibits the harder texture, increased weight and less porous structure in compare to the wheat flour or refined wheat flour and most importantly its list desirable taste and flavour limits the use of millets in the bakery industry, millets also contains some element which affect the

absorption of the other nutrients that is why there has a limit under which the millets can be used in the bakery products. **Siroha *et al.*, (2024)**

ECONOMIC IMPACT OF MILLET PRODUCTION

Millets are small-seeded cereal grains that are gaining increased popularity for their numerous health benefits. In recent years, millets have become a popular topic in health and nutrition conversations. This is mainly due to their nutrient-rich composition and the fact that they are gluten-free. According to a recent report from the ***Food and Agriculture Organization (FAO)*** of the United Nations, millets are "nutrient-dense, resilient, and climate-smart." The FAO has declared 2023 as the International Year of Millet in order to raise awareness of the potential of these grains.

The millet sector in India is one of the most important and promising agricultural sectors in the country. Millets are an ancient and traditional agricultural crop, yet they can potentially provide a great deal of economic growth and development for the Indian economy. According to a report by the ***National Bank for Agriculture and Rural Development (NABARD),*** millets are estimated to have a market potential of around Rs 19,000 crore (US$ 2.7 billion).

In addition, the millet sector supports millions of small and marginal farmers, who are the primary producers of millets. Moreover, the millet sector also has a positive impact on the environment. Millet farming is a more sustainable form of agriculture as it requires less water, fertilizers and pesticides compared to other crops. It also helps in maintaining soil fertility and reducing soil erosion. In addition, millet farming helps in maintaining the biodiversity of the region. In conclusion, the millet sector in India has a great potential to contribute to economic growth and development in the country. It provides employment opportunities to millions of people and supports millions of small and marginal farmers. Additionally, it has a positive impact on the environment. **Pathak (2023)**.

From an environmental standpoint, millets stand out for their resource efficiency, requiring less water and fewer chemical inputs compared to conventional crops. This characteristic not only supportssustainable agricultural practices but also contributesto climate resilience, crucial for regions prone to climatic extremes. Culturally, promoting millet consumption can reconnect communities with traditional dietary practices, especially in regions like Maharashtra where millets have historical significance as staple foods. **Shekar & Upadhaya (2024).**

In terms of economic advantages, millet production offers a solution to the issue of disguised unemployment. By encouraging surplus labour currently engaged in wheat and paddy fields to shift towards millet cultivation, workers can earn rewards based on their marginal productivity rather than their average output. India holds a dominant position as the world's leading producer of millet, contributing nearly 41% of the global output as of 21-22 (***India Data Insights, Millets in India, IYM 2023***). The current millet market size is at 11.5 billion USD and with a compound annual growth rate (CAGR) of 4.60% The projected surge in global demand for millet, estimated to reach a staggering $14.4 billion USD by 2029 (Millet market size and share analysis – Growth trends and forecasts 2024- 29, Mordor intelligence) presents a significant opportunity for India's agricultural sector.

ENVIRONMENTAL IMPACT

Millets can also help to reduce soil erosion due to their short growth cycle and deep root systems. The short growth cycle means that the crop can be harvested quickly, reducing the amount of time that the soil is exposed to the elements and reducing the amount of topsoil that is washed away. The deep root systems of millets also allow them to absorb more water and nutrients from the soil, reducing the need for irrigation and helping to maintain soil structure and fertility. Millets also have the potential to reduce greenhouse gas emissions. Millets are a C4 crop, meaning that they are able to capture more carbon from the**.** atmosphere than other cereal crops. This increases the amount of carbon that is stored in the soil and reduces the amount of carbon dioxide that is released into the atmosphere. **Pathak, (2023).**

Millets being C crops are having higher efficiency in absorbing and utilizing CO and efficient users of water and nutrients for growth and highly tolerant to warmer temperatures and to some extent to flooding. **Basavaraj *et al.*, (2010).**

Millets are photo-insensitive and resilient to climate change. They are hardy, resilient crops that have low carbon and water foot print. Under adverse climatic conditions they are often last standing thereby providing a good risk management option particularly for resource poor small farmers. Millet grows with minimal fertilizers and pesticides and survive with less water; they only need 350-400 mm annual rainfall. Millets are also unique due to their short growing season and crop duration as little as 65 days putting less stress on environment. **Gowda *et al.*, (2019).**

CONCLUSION

Millet flour presents a promising alternative to refined wheat flour in bakery products, offering numerous nutritional and functional benefits. Despite challenges related to sensory properties and consumer acceptance, the increased awareness of millets' health benefits could encourage their wider use in bakery products. Moreover, the economic and environmental advantages of millet cultivation make it a sustainable choice for future food systems. Continued research and development to overcome technological challenges and improve the sensory qualities of millet-based products will be crucial for their integration into mainstream markets.

The substitution of refined wheat flour with millet flour in bakery products offers numerous nutritional and functional benefits, including improved glycemic control, higher fiber content, and enhanced antioxidant properties. While challenges exist in terms of consumer acceptance, technological adaptation, and product sensory qualities, the potential benefits of incorporating millets into bakery products are significant. With growing awareness and support for sustainable agriculture, millet-based products could play a key role in addressing health concerns and boosting food security.

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