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Development and formulation of multi millet Sweet Nachos: A review

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Abstract
This literature review examines the historical cultivation, processing techniques, health benefits, and innovative applications of millets, with a focus on developing multi-millet sweet nachos. Millets, including pearl millet, kodo millet, and barnyard millet, are valuable sources of essential nutrients such as proteins, fatty acids, minerals, vitamins, dietary fiber, and antioxidants. Pearl millet is noted for its high nutrient content and ability to thrive in harsh climatic conditions, making it a nutritious and affordable option for low-income populations. Kodo millet is recognized for its drought tolerance and high levels of fiber and protein, while barnyard millet is celebrated for its digestibility and rich micronutrient content, particularly iron and zinc. Studies highlight the prebiotic potential of millet-based foods and their ability to enhance probiotic viability. Various processing techniques, such as germination, fermentation, and dehulling, impact the nutritional profile of these millets. Health benefits are underscored, particularly in regions facing food insecurity. Innovative products like ice cream cones made from composite millet flours and nachos incorporating pumpkin seed powder demonstrate the versatility of millets in the food industry. This review emphasizes the need for continued research to optimize millet processing and promote their global consumption for enhanced nutrition and sustainability.

Keywords: Millets, pearl millet, Kodo millet, barnyard millet, multi-millet sweet nachos, nutritional benefits, processing techniques

1. Introduction

Millets, small-seeded grasses grown for millennia in the arid regions of Asia and Africa, are highly valued for their ability to withstand harsh climates and minimal water needs. These crops are essential for food security and sustainable agriculture, particularly in developing countries, because they can grow in poor soils and offer a rich nutritional profile that includes proteins, fatty acids, minerals, vitamins, dietary fiber, and antioxidants. The food industry is increasingly recognizing the potential of millets, with innovative processing techniques and product development broadening their applications beyond traditional uses. For example, millet flours are being incorporated into products like ice cream cones and nachos, showcasing their versatility and potential for creating nutritious and appealing food items.

1.1 Pearl Millet nutritional value and product

Pearl millet (*Pennisetum glaucum*), also known by various local names such as bajra, bajri, sajje, kambu, kamban, and sajjalu, is a versatile cereal crop from the Poaceae family. It is notable for its deep root system, which allows efficient nutrient extraction, making it more nutritious than cereals like wheat, rice, maize, and sorghum. Pearl millet is rich in essential minerals such as iron, zinc, magnesium, copper, manganese, potassium, and phosphorus. It provides a significant energy source with 361 Kcal per 100 grams and contains a high fiber content of 1.2 grams per 100 grams (Singh *et al.*, 2018) [14]. Additionally, it has a higher protein content compared to other cereals (Taylor and Emmabux, 2008) [17] and is a good source of vitamins B and A, folic acid, calcium, and magnesium (Pattanashett *et al.*, 2016) [11]. However, its high-fat content can affect its shelf life. Pearl millet is used in various traditional dishes such as porridge and flatbreads (roti). It is also utilized in the production of alcoholic beverages like opaque beer and non-alcoholic drinks such as pombe and pito (Adebiyi *et al.*, 2018) [1]. In India, pearl millet flour is commonly used to make items like laddoo, chips, wadi, bread, and cake.

1.2 Barnyard Millet: Barnyard millet (*Echinochloa species*) is an ancient crop cultivated in warm and temperate regions, particularly in Asia, including India, China, Japan, and Korea. It ranks as the fourth most produced minor millet, playing a crucial role in ensuring food security for many impoverished communities worldwide. India is the largest producer of barnyard millet, with an area of 0.146 million hectares and a production of 0.147 million tonnes, achieving an average productivity of 1034 kg/ha over the past three years (IIMR, 2018). Barnyard millet (Echinochloa frumentacea), also known as Japanese barnyard millet, Ooda, Oadalu, Sawan, and Sanwank, is a significant minor millet. It contains a fair amount of protein (12 percent), which is highly digestible (81.13 percent), along with a low carbohydrate content (58.56 percent) with slow digestibility (25.88 percent) (Veena, 2003). Additionally, barnyard millet is rich in dietary fiber (13 percent), phytochemicals, and antioxidants (Bouis, 2000) [2].

1.3 Kodo millet

Kodo millet (*Paspalum scrobiculatum*) is a gluten-free grain, making it ideal for those with gluten intolerance. Its high lecithin content promotes digestion and supports the nervous system. Regular consumption of Kodo millet can benefit postmenopausal women by addressing cardiovascular issues such as high blood pressure and elevated cholesterol levels. Rich in antioxidants, Kodo millet helps combat oxidative stress and manage glucose levels in type-2 diabetes. It is also effective in treating conditions such as asthma, migraines, hypertension, heart attacks, atherosclerosis, and diabetic heart disease. With the growing population in developing countries, research into millet-based products is increasingly important to fully utilize these health benefits.

2. Review of literature

2.1 Millet history and cultivation

Issoufou Amadou *et al*. (2013) [6] emphasize the nutritional benefits and processing of millets, which are vital food sources in arid and semi-arid regions. Millets are excellent sources of energy and provide essential nutrients, including proteins, fatty acids, minerals, vitamins, dietary fiber, and polyphenols. The proteins in millets are particularly rich in essential amino acids, especially sulfur-containing ones like methionine and cysteine. Additionally, millets contain antioxidants such as phenolic acids and glycated flavonoids. Millet-based foods have the potential to act as prebiotics, improving the viability and functionality of probiotics, thus offering significant health benefits. Enhancing these properties is essential for expanding the use of millet grains, and future efforts should focus on increasing millet consumption in developed countries to potentially drive an industrial shift.

Palak Mahajan *et al*. (2021) [10] highlight the growing global popularity of millets and their products, owing to their numerous health benefits. Starch, which makes up about 70% of millet grain, significantly influences the quality of millet-based food items. This review explores the chemical composition, characterization, structural chemistry, digestibility, hydrolysis, and modification methods of millet starches. It also examines the diverse applications of both native and modified starches in the food industry. Despite being a major component, millet starch is often overlooked as a raw material for starch production, unlike more conventional sources. Millet starches, like other types of starch, primarily serve as structuring agents, texture modifiers, binders, and viscosity regulators.

Sinthia Afsana Kheya *et al*. (2023) [16] explore the significance of millets as essential crops for tropical regions, particularly in their ability to endure various climate change-related stresses. With the Food and Agricultural Organization of the United Nations (FAO) declaring 2023 the "International Year of Millets," the review highlights both the potential benefits and key challenges of promoting millet cultivation in these areas. Major obstacles include insufficient research and development, inadequate infrastructure and resources, weak market connections and demand, and a general lack of awareness about the nutritional and environmental benefits of millets. The review suggests opportunities and strategies for enhancing millet cultivation, especially in Bangladesh. Future research should focus on increasing millet yield and profitability by developing improved varieties, implementing better farming practices, and using modern technologies. Overall, millets have the potential to significantly contribute to achieving the Sustainable Development Goals (SDGs) in many tropical countries, particularly India and Bangladesh.

2.2 Processing techniques of millet

N.A. Nanje Gowda (2022) [4] addresses the modern processing techniques of Indian millets and their effects on nutritional properties. With billions globally suffering from food insecurity and malnutrition, the United Nations aims to eradicate hunger by 2030, yet this goal remains distant. Climate change, population growth, and economic challenges have adversely affected food security, leading to issues of both undernutrition and overnutrition in many countries. Therefore, transforming the food system is essential for ensuring food and nutrition security. The study highlights that germination and fermentation enhance the nutritional profile of millets, while excessive dehulling, polishing, and milling diminish their dietary fiber and micronutrient content. Understanding how processing impacts the nutrient value of millets can guide the food industry, researchers, and consumers in choosing suitable techniques to optimize nutrient retention, improve bioavailability, and address food and nutrition security effectively.

Laraib Yousaf *et al*. (2021) [7] review the nutritional and functional transformations that occur in millets during processing. Millets are rich in essential nutrients, including proteins, carbohydrates, fats, minerals, vitamins, and bioactive compounds. However, the content and function of these nutrients and bioactive compounds can be significantly affected by food processing methods such as decortication/dehulling, soaking, germination/malting, milling, and fermentation. The findings suggest that these processing techniques can be beneficial in addressing undernourishment and other health-related issues. Additionally, the review offers comprehensive insights into millet processing, which can be valuable for the food industry, consumers, and researchers.

Savita Rani *et al*. (2018) [14] examine the processing of pearl millet (*Pennisetum glaucum*), highlighting its superior nutrient content compared to other major cereal crops. However, its utilization is hindered by the presence of anti-nutritional factors such as phytates, tannins, and polyphenols, which reduce mineral bioavailability, and by poor storage stability due to high lipase activity. This literature review, spanning studies from 1983 to 2017, investigates the effectiveness of various processing methods in enhancing the nutritional value of pearl millet by reducing these anti-nutritional compounds. The review details how processing impacts the nutrient and anti-nutrient profiles of pearl millet. It concludes that proper processing methods are essential for improving both the nutritional availability and storage stability of pearl millet flour and products. Therefore, adopting suitable processing techniques is crucial for promoting the commercial use of pearl millet in food formulations and enhancing food security.

S. Chandraprabha and Sharon C. L. (2021) [15] focus on optimizing the germination conditions for barnyard millet to enhance its nutritional value and acceptability. Barnyard millet, a highly digestible minor millet (81.13 percent digestibility), contains a good amount of protein (12 percent) and low carbohydrate content (58.56 percent) with slow digestibility (25.88 percent). Germination can significantly improve its nutritive value and taste. This study aimed to identify optimal germination conditions to maximize these benefits. The barnyard millet was cleaned, soaked for varying time intervals, and then germinated for 24 hours. The dried grains were powdered, sieved, and subjected to organoleptic evaluation. Parameters such as moisture absorption, sprout length, malt yield, and germination percentage were measured. The best results, based on organoleptic evaluation, were achieved with 10 hours of soaking followed by 24 hours of germination, and this method was used for producing value-added products. The study found that increasing soaking time from 4 to 18 hours increased moisture absorption from 35.16 to 54.12 percent, with the maximum sprout length of 0.4 cm observed at 18 hours of soaking. Malt yield varied from 59.62 to 71.54 percent depending on the soaking time.

2.3 Health benefits of millet

Monika Satankar and colleagues (2020) [13] conducted a comprehensive review on pearl millet, highlighting its significance as a nutrient-rich cereal capable of thriving in harsh climatic conditions. They emphasized that sudden climate changes and natural disasters can disrupt food security, leading to increased food prices and reduced availability. In such scenarios, pearl millet emerges as a nutritious and affordable alternative for low-income populations, supporting a healthy and active lifestyle. Despite its nutritional advantages, the utilization of pearl millet is limited by the presence of anti-nutritional factors and its poor storage quality.

Vellaichamy Gandhimeyyan Renganathan and colleagues (2020) [13] discuss the increasing importance of barnyard millet (*Echinochloa species*) as a minor millet crop in Asia, with a significant rise in global production. They point out that barnyard millet is an excellent source of protein, carbohydrates, fiber, and is particularly rich in micronutrients like iron and zinc compared to other major cereals. However, despite its nutritional and agronomic advantages, barnyard millet remains underutilized. There has been minimal research on this crop's characteristics over the past decades. Therefore, there is a need for more focused research efforts to characterize its germplasm resources, identify trait-specific donors, develop mapping populations, and discover relevant QTLs/genes.

2.4 Millet based products

Roopal Mhatre and colleagues (2020) [13] conducted a comparative study on ice cream cones made from refined wheat flour, ragi, buckwheat, bajra, amaranth, and a composite flour blend excluding refined wheat flour. To create the composite flour ice cream cone, refined wheat flour was completely replaced with a mixture consisting of 40% ragi, 35% buckwheat, 15% bajra, and 10% amaranth flour. The study examined the impact of incorporating egg white on yield percentage, baking time, and the ice cream holding duration. The composite flour cones remained crisp and successfully held ice cream for 37 minutes and 35 seconds.

Pratik Anant Thakar (2023) [9] developed nachos using a blend of pumpkin seed powder, sorghum (jowar) flour, maize (zea mays) flour, and chickpea (besan) flour. Pumpkin seed powder was incorporated into the dough in varying amounts (10%, 20%, 30%). The dough was used to prepare tortillas, which were then fried to make nachos. Different formulations were tested by varying the maize flour content at 40%, 30%, and 20%. The resulting nachos had a moisture content of 4.84% and an ash content of 3.87%. They were found to contain 26.01% protein, 37.23% carbohydrates, 28.02% fat, and provided 505.14 kcal of energy.

3. Conclusion

The comprehensive review of the historical cultivation, nutritional benefits, and innovative applications of millets underscores their significant potential in addressing food security and promoting sustainable agriculture. Millets, such as pearl millet, kodo millet, and barnyard millet, are highly valued for their rich nutrient profiles, including essential proteins, fatty acids, minerals, vitamins, dietary fiber, and antioxidants. These attributes make millets an excellent choice for enhancing nutrition, especially in regions prone to food insecurity.

Pearl millet stands out for its robust nutrient content and resilience in harsh climatic conditions, offering a viable and nutritious option for low-income populations. Kodo millet's high fiber and protein levels, coupled with its drought tolerance, make it an essential crop for sustainable agriculture. Barnyard millet is notable for its digestibility and micronutrient richness, particularly in iron and zinc, which are crucial for combating malnutrition.

The review highlights various processing techniques, such as germination, fermentation, and dehulling, that significantly impact the nutritional profile of millets. These methods can enhance the bioavailability of nutrients and reduce anti-nutritional factors, thereby improving the overall health benefits of millet-based foods. Innovative products like millet-based ice cream cones and nachos incorporating pumpkin seed powder exemplify the versatility of millets in the food industry.

Future research is essential to optimize millet processing techniques and promote their global consumption. This will not only improve nutrition but also contribute to environmental sustainability and economic development in developing regions. Emphasizing millet cultivation and consumption aligns with global efforts to achieve food security and nutritional adequacy, supporting the broader goals of sustainable development.

In summary, millets hold substantial promise as a cornerstone of sustainable and nutritious food systems, warranting increased attention and investment in their research, cultivation, and innovative applications.

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