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MILLET FOOD WASTE AS MEDICINE FOR MANAGEMENT OF LIFESTYLE DISORDERS

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ABSTRACT: Plant foods are wasted especially in millets as they are not required in that particular product processing. From the cultivation of millet to its processing and consumption of the final product, a significant amount of waste is generated. Wasted foods are not spoilt foods and still have the potential to be used for the second time as food. But unfortunately, the fate of waste is always landfills which surely create a menace. By this we are throwing nutria rich foods on one hand and on the hidden hunger is on the rise. The challenge that lies in front is converting this waste into a nutria rich and nutraceutical food again/ specialty ingredient for functional foods or super foods but should ensure zero waste this time. Millet has gained momentum and rejuvenated in the recent past. Even then millets for its part is also contributing to waste generation that needs attention. (No of words - 150).

INTRODUCTION: Millets are small-seeded grains, designated as coarse grains. The most common and important millets for food include sorghum (*Sorghum bicolor* L.) pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine carocana*), proso millet (*Panicum miliaceum*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setariaitalica*), little millet (*Panicum sumatrense*), barnyard millet (*Echinochloa frumentacea*) and to a certain extent, teff (*Eragrostis tef*) and fonio (*Digitaris exilis*). Millets were among the first crops to be domesticated in India with several evidence of its consumption during the Indus valley civilization.

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Being grown in more than 130 countries at present, millets are considered traditional food for more than half a billion people across Asia and Africa. Millets are important by the virtue of its mammoth potential to generate livelihoods, increase farmers' income and ensure food & nutritional security all over the world. With increasing attention on coarse grains, demand for millets based functional therapeutic foods has gained momentum. India is soon to serve as the hub for millets. The global millets market is projected to register a CAGR of 4.5% during the forecast period between 2021-2026.

The Economic Survey 2023 highlighted that India produces over 50.9 million tonnes (as per fourth advance estimate) of millet, which accounts for 80 per cent of Asia's and 20 per cent of global production. India is the topmost producer of Barnyard (99.9%), Finger (53.3%), Kodomillet (100%), little millet (100%) and pearl millet (44.5%), producing about 12.46 million metric tonnes from an area of 8.87 million hectares [26]. The food industry and researchers have become interested in developing nutrient-dense and fiber-rich food due to the increasing health complications associated with a sedentary lifestyle and excessive consumption of refined, processed foods. Consuming refined foods leads to a reduction in fiber intake and does not meet the recommended dietary allowance for individuals. The absence of fiber-rich foods in one's diet can contribute to the development of diseases such as obesity and its associated complications. Furthermore, malnutrition or micronutrient deficiencies are prevalent in all age groups. Given these circumstances, consumers, researchers, and industrialist are focused on creating functional foods that contain innovative functional ingredients. This is one of the reason where millets have gained momentum as they serve as one of the ingredient for functional foods. Not only functional and nutracutical ingredient millets are in demand as natural food additive, food fortificant for micronutrients and millet material science is the future of millets. Millets as a grain and flour can serve as a functional food which is beyond doubt, but in the event of converting millet into a functional food waste is generated. These wastes have the potential to be re used as food for the second time as we are in a position that we cannot afford waste in millets.

Structure of Millets: The cereal grains and millets exhibit a comparable structure consisting of three primary components known as Pericarp (outer layer), Endosperm (Starchy part), and germ (oily part) Millets are commonly classified into utricles and caryopses. Utricle type millets feature a pericarp that can be easily removed, enveloping the seed; notably, foxtail, proso, and finger millet grains belong to this category. The utricle pericarp forms a sack-like enclosure around the inner endosperm with a single point attachment, facilitating easy removal. Conversely, sorghum and pearl millets are categorized as caryopses, wherein the pericarp strongly adheres to the seed. Consequently, a higher level of external energy is necessary to detach the pericarp from the endosperm in this scenario. Additionally, the presence of a pigmented testa is observable in finger millet and occasionally in pearl millet, while fonio and proso millets lack a pigmented testa [7].

Millet Processing: Millets, like other grains, necessitate dehulling and polishing due to their high consumer preference. The processing of millet grains to resemble rice or wheat involves dehulling, polishing, flour preparation, and the creation of various products. In contrast to rice and wheat, millet flour, including the husk and bran, is pulverized for applications in beverages and health mixes, after undergoing a sieving process to yield clean flour devoid of husk and bran. Despite the loss of nutrients and nutraceuticals, this process generates waste. Significant quantities of millet waste are produced during various primary processing stages such as decortication, dehusking, debraning, milling, soaking, germination, malting, fermentation, puffing, flaking, and other methods [24].

Waste Generation from Millets:

Milling Wastes: The processing of millets facilitates the transformation of grains into more easily consumable food products. The processing of millet grains serves to preserve and enrich their nutritional content while also encouraging consumption. Millet milling is carried out to yield both raw millet rice and parboiled millet rice. Due to its small size in comparison to other cereals, the decortication of millet grains presents challenges; Similarly, the cooking of millet in its whole grain form like rice has proven to be problematic. Therefore hydrothermal processing of millets becomes essential where in the endosperm texture is strengthened, facilitating decortications and reduces the cooking time [23].

The morphology of millets presents a considerable challenge to both millers and manufacturers of millet milling machinery. The reduced size of millet grains plays a notable role in the considerable generation of millet bran during the milling process [25]. The quantity of bran formed depends on the structural composition of millets and processing parameters such as dehulling or milling time, moisture levels, and related aspects. When examining diverse millet varieties, some types demonstrate a higher content of bran compared to others. Furthermore, the proportion of the three constituents of the kernel, which also varies depending on the type of millet, impacts the firmness and susceptibility to enzymes. In pearl millet, the allocation of endosperm, germ, and pericarp accounts for 7%, 17%, and 8% respectively. Pearl millet stands out among all cereals due to its relatively larger germ fraction, resulting in an endosperm-to-germ ratio of 4.5:1, while sorghum exhibits a ratio of 8.4:1. Conversely, finger and proso millets possess a smaller germ size, leading to endosperm-to-germ ratios ranging from 11:1 to 12: [30]. With the exception of finger millet, the others typically feature a single-thick seed coat firmly adhering to the starchy endosperm and aleurone layer. In contrast, finger millet presents a seed coat consisting of five cell layers, with a maximum thickness ranging from 10.8 to 24.2 µm. Notably, the husk content in foxtail millet is notably lower at 13.5% compared to barnyard millet at 23% and kodo millet at 37%. Similarly, sorghum showcases germ and pericarp components at 9.4% and 6.5% respectively.

Small millet dehulling in the 1990s and early 2000s primarily involved the use of abrasive roller type machines due to the unavailability of dedicated dehullers for small millets during that period. This method resulted in the removal of not only the husk but also the bran and a small portion of the endosperm, leading to a reduction in nutrient content. Studies comparing de-hulled millets from abrasive mills and centrifugal de-hullers, finding that the centrifugal method, which retains the bran, achieved about 10% higher millet recovery with a de-hulling efficiency of 95% compared to abrasive mills. The breakage rates were notably lower in the centrifugal method at 4-5% compared to 1-2% in the abrasive method. These findings suggest that regardless of grain size, morphology, or advancements in dehulling machinery, the generation of waste in the form of husk, bran, broken grains, and similar by-products remains unavoidable [28].

Milling of millets holds significant importance from a nutritional perspective. The process of milling is crucial as it aids in the elimination of anti-nutritional factors. Dehulling plays a vital role in reducing the levels of phytic acid, tannins, polyphenols, and other anti-nutrients, which are primarily concentrated in the outer layers of the grain, such as the pericarp and aleurone layer. Furthermore, the decortication process leads to a decrease in essential nutrients like minerals, fibers, and phenols by removing the pericarp, thus diminishing the desirability of millet as a functional food. Nevertheless, the decortication of millet results in a notable decline in bioactive compounds, given that a significant proportion of phenolic compounds are situated in the seed coat[10]As millet milling is inevitable so its associated waste generation is also in evitable.

Soaking Wastes: Soaking is a widely employed technique that facilitates the reduction of phytic acid levels inherent in the bran and endosperm segments of millet grains, thereby enhancing the mineral bioavailability. Immersing millet in water for a specific duration has been shown to markedly decrease phytate concentrations. For instance, an 8-hour water soak resulted in a 5.4% decline in phytate content. Moreover, subjecting finger millet seeds to varying temperatures and durations of soaking led to a reduction in anti-nutrients such as phytate, coupled with an augmentation in mineral levels. Another investigation demonstrated that soaking pearl millet followed by air plasma treatment further diminished phytic acid content and increased the extractable iron levels. The process of soaking serves as an efficient approach to diminish phytic acid content in millet grains and enhance mineral accessibility [1]. This technique produces by-products, with the unfilled and chaff grains floating on the surface, resulting in a 1% loss during processing. The chaff grains produced from millets consist of husk and bran remnants, necessitating efforts to segregate them for potential reutilization as food.

Germination/ Malting Wastes: Germination represents a conventional procedure characterized by a modest operational expenditure and a technology that is readily adaptable. Through this process, the structure of the grain's kernel is softened, thereby enriching the nutritional composition of the grain. The utilization of germination as a method is aimed at producing malt abundant in nutrients, which can subsequently be employed in the creation of diverse nutritional food items, blended flours, and supplementary food products. Emerging germination systems, supported by sophisticated control mechanisms, contribute to the production of various nutritional food products, composite flours and complementary food items.

The sprouting of millets assumes a crucial role in the formulation of healthful and nutritious beverages. A significant challenge encountered in this sector pertains to the time-sensitive nature of the germination process. Even millets obtained from identical suppliers may exhibit variations in the time required for germination. For instance, a processing facility dedicated to health mix production allocates 36 hours to germination and an additional 24 hours for subsequent operational tasks to achieve the final output. Notably, a germination period of 36 hours results in a germination rate of only 70%, leaving 30% of the grains unused. Although these grains are not spoiled, they are deemed wasteful due to their failure to germinate. Given more time, these grains would eventually sprout; however, logistical constraints necessitate adherence to fixed timelines for product delivery. Consequently, the malting process of millets inadvertently gives rise to wastage. The nutrients inherent in these grains remain consistent with those found in raw grains intended for consumption. Moreover, conventional methods of household-level processing, such as cooking and fermentation, have been proven effective in diminishing the phytic acid content across various millet variants [17].

Puffing/ Popping Wastes: Popping or puffing is a conventional technique utilized in the processing of expanded cereals to create ready-to-eat products. Various cereal processing methods are suitable for millet grains to produce ready-to-eat items, involving traditional techniques such as flaking and popping, as well as modern approaches like roller drying and extrusion cooking. The popped foxtail millet displays reduced levels of crude fiber and fat in comparison to raw millet; this discrepancy is attributed to the processing impact, given that fat and fiber are predominantly found in the grain's outer layer, which is more susceptible to alterations compared to other nutrients residing in the inner layer. Consequently, the adoption of innovative technology under optimized conditions facilitates large-scale millet production. During the puffing process, unpuffed grains are generated as byproducts. It is observed that due to the diminutive size of millet grains, the maximum puffing efficiency achievable is merely 60%. The remaining 40% remains unpuffed, with approximately 2% of this fraction comprising burnt grains. Given that puffing facilities are typically small-scale operations, there is no significant endeavor to locate buyers for the unpuffed grains. Consequently, this nutritional resource is discarded as waste [6].

Nutritional and Nutraceutical Properties of Millet Wastes: Bran constitutes the outer layer of the majority of cereal grains, known for its high nutrient density including proteins, omega 3 and omega 6 fatty acids, and antioxidants. Cereal bran serves as a valuable source of dietary fiber, enhancing the nutritional and nutraceutical profile of whole grains. Millet bran, a derivative of millet-based food processing, offers similar benefits [20].

Decortication of millet grains is a common practice to enhance the palatability and nutritional value of porridge/flour for human consumption. This process results in a loss of approximately 35% of the total grain weight, leading to the production of a significant amount of bran by-product Nevertheless, millet bran remains a consumable ingredient rich in dietary fiber, micronutrients, and bioactive compounds The nutritional value of bran tends to degrade over time due to hydrolytic and oxidative transformations of lipids, impacting its flavor and applicability in the food sector. Furthermore, excessive production of lipid peroxidation by-products can induce cytotoxic effects associated with various health conditions such as cardiovascular diseases, cancer, neurodegenerative disorders, and aging. Therefore, evaluating the storage stability of bran intended for food applications is crucial. The aleurone layer is considered to be the least extensible tissue in bran. In millets, there exists a single-layer aleurone that is rich in proteins, fats, and minerals. Directly beneath the aleurone layer, there is at least one layer of peripheral endosperm, known for its higher protein content compared to the rest of the endosperm. Conversely, the germ is comprised of proteins, fats, and minerals. Given the chemical composition and particle size of PBF, it is presumed to be predominantly composed of an aleurone layer and germ.

Millet Waste as Food Again:

Millet Bran as Medicinal Food: Bran is a rich source of nutrients, particularly containing dietary fiber and phytochemicals known for their antioxidant properties. The nutritional analysis of millets remains limited, highlighting the need for further comprehensive research to fully exploit the benefits of byproducts and waste generated during millet processing. Despite incomplete literature on their nutritional and phytochemical profiles, the available data adequately demonstrates the nutrient density and antioxidant capacity of various millet brans. The process of sieving, either alone or in conjunction with other separation techniques like air-classification or electrostatic separation, can be employed to selectively gather fractions abundant in different bran layers. The utilization of bran fractions containing concentrated specific components can enhance the nutritional value of end-use food products [8].

Utilizing millet waste for food purposes requires prior reduction of anti-nutritional factors in the bran and husk, while preserving their nutritional and nutraceutical components. Various processing techniques can be employed to enhance the nutritional value and functional properties of millet bran. Bio-processing methods like soaking, germination, enzymatic hydrolysis, and fermentation have shown effectiveness in modifying the compositional parameters and functional attributes of millets [18].

These techniques contribute to the breakdown of polysaccharides and proteins, ultimately improving the functionality and bioactivities of millet bran. Non-thermal processing approaches, including germination, fermentation, high hydrostatic pressure, ultrasonication, irradiation, pulsed light, and cold plasma, have also been utilized to enhance the nutritional quality and storage stability of millets [27]. These methods have proven effective in enhancing the nutritional properties, antioxidant activity, and sensory attributes of millets, resulting in reduced levels of tannins and phytic acid. Moreover, novel processing methods such as microwaving, ultrasound treatment, and high-pressure processing have been shown to significantly impact the structure and quality of millet proteins, offering opportunities to enhance the nutritional value, bioavailability, and functionality of millet bran for the production of value-added food products. Consequently, bran could be processed into functional foods, particularly gluten-free (GF) options, akin to the approach demonstrated with rice and quinoa bran fractions.

Pearl Millet Bran as Medicinal Food: The utilization of millet bran, a residue from the millet milling process, remains relatively unexplored despite its rich content of polyphenols, dietary fiber, minerals, and being gluten-free [4] Extracting dietary fiber from pearl millet bran could prove to be a valuable method for waste utilization with commercial viability on an industrial scale. This research aimed to compare various green techniques (enzyme-assisted extraction, ultrasound-assisted extraction, microwave-assisted extraction, ultrasound-assisted enzyme extraction, and microwave-assisted enzyme extraction) for obtaining dietary fiber concentrate from pearl millet bran, while also examining the microstructural and functional properties through ultrasound-assisted enzymatic extraction. The combination of ultrasound treatment and enzymatic extraction at specific settings such as amplitude (35%), temperature (50 °C), and liquid to solid ratio (40:1) with a treatment time of 10 minutes resulted in the highest extraction yield (78.8 %, w/w) of total dietary fiber from pearl millet bran. The dietary fiber derived from pearl millet bran exhibited notable water holding capacity (4.04 g/g and 3.04 g/g) and oil holding capacity (5.33 g/g and 2.42 g/g), indicating its potential for use in the development of functional food products [14].

Proso Millet Bran as Medicinal Food: Decortication of proso millet resulted in decreased ash and fiber content, with no notable impact on fat and protein content, potentially due to variations in decortication methods employed. The intermediate layer of bran (known as testa or seed coat) displayed high plasticity and extensibility, making it resistant to fragmentation during mechanical processing, consequently yielding coarser particles. In proso millet, the pericarp is typically attached to the seed at a single point and tends to detach from the seed coat, which is robust and well-developed. Both the seed coat and pericarp are abundant in insoluble dietary fiber [8]. This proves the scope that proso millet bran can be used as a natural additive for development of fibre rich foods.

Finger Millet Bran as Medicinal Food: The pericarp or seed coat of finger millet is the residue from millet grain processing and contains a substantial amount of dietary fiber, minerals, and phytochemicals. Typically, finger millet is processed together with its seed coat, where most of the nutrients, dietary fiber, and bioactive compounds are concentrated, thus providing nutritional and health advantages. The utilization of finger millet seed coat (FMSC) in creating composite flour for bakery items is feasible. The seed coat is rich in tannins, which contribute to the characteristic astringency of finger millet-based products. Foods rich in finger millet help in managing diabetes, obesity, and associated medical conditions. A diet high in FMSC has been demonstrated to reduce inflammation, enhance plasma lipid profile, lower oxidative stress, regulate the expression levels of various genes related to obesity, and promote the growth of beneficial gut bacteria like *Roseburia*, *Bifidobacteria* and *Lactobacillus spp* [22].

Barnyard Millet bran as Medicinal Food: The barnyard millet underwent a cleaning process to eliminate the bran through milling. Within one kilogram of whole barnyard millet, there was a presence of 350 grams of bran. Subsequently, the sample was meticulously cleaned, dried in the shade, manually ground, and sifted through a 60-mesh sieve (BSS) to gather the bran. The impact of different chemical treatment methods on barnyard millet bran was assessed for its antinutritional and proximate composition. Various chemical treatments, especially those involving calcium hydroxide and hot water, on barnyard millet bran led to a reduction in antinutrient components such as trypsin inhibitor, lipase activity, phytates, *etc*., compared to raw barnyard millet bran.

Furthermore, treated bran exhibited stabilized levels of dietary fiber, protein, and ash content compared to other treated bran samples. The sensory qualities of rusk with an 85:15 ratio and muffin with a 75:25 ratio incorporating BMB were well-received by the evaluation panel. Although the inclusion of BMB marginally increased the hardness of rusk and enhanced the strength of muffins, the study demonstrated a significant increase in protein and dietary fiber content with higher BMB (Barnyard millet bran) incorporation. Consequently, the addition of BMB in baked goods formulations is deemed suitable for the baking process and fortification, as it can potentially serve as a partial substitute for wheat flour and function as a functional ingredient in formulated bakery products to enhance nutritional value while preserving palatability [20].

Other Millet Bran as Medicinal Food: The minor millet known as kodo millet is characterized by its resilient nature, possessing seven distinct layers of fiber that, upon dehulling, polishing, and milling, yield substantial amounts of bran during the processing stages. The bran of kodo millet showcases an impressive total dietary fiber content falling within the range of 48% to 61% and total phenolic compounds measuring at 449 mg GAE/100g. Studies have indicated that sorghum bran typically contains a dietary fiber content varying from 40% to 45%. Various millet brans such as sorghum, finger millet, kodo, proso, and barnyard have exhibited a notable glucose binding ability when their fiber content is extracted, consequently delaying the absorption of glucose and suggesting the hypoglycemic properties associated with millet brans [5]. Experiments involving the supplementation of kodo millet bran into standard feed formulations for mice have shown promising results, as it effectively prevented the elevation of blood cholesterol and lipid profile, while simultaneously enhancing glucose tolerance and increasing the population of beneficial gut microflora, including *Lactobacillus sp.*, *Bifidobacteria*, *Roseburia spp.*, and *A. muciniphila* [26].

Incorporating finger millet bran into the high-fat diet of albino rats for a duration of 12 weeks resulted in a significant reduction in weight compared to the control group. Furthermore, the consumption of bran led to the prevention of lipid peroxidation, improved glucose clearance, and promoted the growth of beneficial gut bacteria, specifically *Lactobacillus*, *Bifidobacteria*, and *Roseburia*. The findings from the study highlight the potential of finger millet bran as a functional ingredient in the development of therapeutic foods with hypoglycemic and hypocholesterolemic properties. Overall, the higher dietary fiber content found in a variety of millet brans suggests their suitability for inclusion in dietary management strategies targeting obesity, diabetes mellitus, and cardiovascular diseases.

Phenolic content ranging from 235 to 837 mg/100 g was observed in sorghum, finger, foxtail, little, and pearl millet. The occurrence of phytic acid is a common feature in millet brans, with levels ranging from 2 – 4 g/100 g in sorghum, finger, foxtail, little, and pearl millets [19, 21]. Millet brans also exhibited phytonutrients such as tannins, flavonoids, anthocyanins, in addition to phytic acid and phenols [15]. The advantages of these phytonutrients and their antioxidant capacity are widely recognized. Research revealed that anthocyanins, specifically apigenindin and luteolindin extracted from sorghum millet bran, demonstrated anti-cancer properties against colon cancer. In conjunction with polyphenols, little millet bran was found to contain α-tocopherols, contributing to its antioxidant function. The health benefits associated with millet brans can be attributed to the presence of antioxidants and dietary fiber components present in substantial quantities in millet brans, alongside other essential nutrients such as carbohydrates, protein, fat, minerals, and vitamins, rendering them a unique ingredient in the formulation of therapeutic foods.

Millet Waste as Nutraceutical Foods: Nutraceuticals are food items or food products that offer health benefits and therapeutic advantages, encompassing the prevention and treatment of diseases. These can be classified into various types such as dietary fiber, prebiotics, probiotics, polyunsaturated fatty acids, antioxidants, and herbal natural foods. The utilization of nutraceuticals has a favorable influence on immune and cardiovascular well-being, in addition to playing a role in averting infections and cancer. They are perceived as a substitute for contemporary medicine, diminishing the necessity for traditional medications and thereby lessening the probability of adverse repercussions. Nutraceuticals substantially contribute to the economic progress of emerging nations like India. They form part of the expanding functional food sector, which strives to enhance health and enhance overall wellness through the bioactive components present in food items. Refinements have been made to millet brans, specifically finger millet bran and kodo millet bran, to eliminate fat and anti-nutrients, resulting in modified cereal bran (MCB) that displays promise in mitigating obesity induced by a high-fat diet and the accompanying health issues [15].

The potential of millet bran as a nutraceutical supplement has been the subject of research. Various investigations have illustrated the beneficial impacts of modified cereal brans derived from finger millet, kodo millet, and rice bran in averting obesity caused by a high-fat diet and the related metabolic complexities [7]. Millet bran protein hydrolysate (MBPH) has also demonstrated a shielding effect against alcoholic fatty liver disease by lessening the uptake of fatty acids and the accumulation of lipids in liver tissue. Furthermore, the incorporation of kodo millet and finger millet bran has been proven to enhance glucose tolerance, ameliorate lipid profile and anti-inflammatory conditions, regulate gene expression related to obesity, modulate gene expression connected to adipogenesis, and enhance the abundance of beneficial gut bacteria, indicating its potential for utilization in the formulation of functional food products.

Millet Waste as Encapsulated Nutraceutical Product: Millet bran is abundant in nutrients and bioactive constituents. Polyphenols serve as crucial active components, yet their characteristics are relatively unstable and susceptible to oxidative breakdown under specific circumstances. An endeavor was undertaken to extract the polyphenols from millet bran using ultrasonic combined with DESs and fabricate microcapsules through their incorporation to investigate their physicochemical attributes. Findings revealed that the overall polyphenol content of millet bran reached 10.58 mg/g through ultrasonic-assisted extraction lasting 30 minutes at 45 °C with a material-liquid ratio of 1:36 g/mL. Subsequent to the preparation of microcapsules, the configuration of millet bran polyphenol microcapsules was scrutinized via scanning electron microscopy, unveiling a sleek outer surface of the microcapsules with uniformly sized particles. The process of microencapsulation substantially enhanced the stability performance of millet bran polyphenols, laying a foundation for the profound exploration and exploitation of millet bran [13].

Millet Waste as Natural Food Additive: The demand for natural antioxidants derived from edible plant origins for the preservation and extension of shelf life of food products is on the rise. Natural antioxidants that are effective, safe, and health-enhancing are increasingly utilized in the production of high-fat food items like mayonnaise and salad dressings to meet the growing preference for chemical-free alternatives. The antioxidative efficacy of polyphenols from Finger millet seed coat against lipid oxidation in mayonnaise was juxtaposed with a synthetic antioxidant (BHT). The research illustrated that FMSC polyphenols (1.0 mg/g) outperformed synthetic antioxidants (BHT) in averting oxidative rancidity in full-fat spreads like mayonnaise over a span of seven weeks at 4 °C [2]. Additionally, the protein and overall mineral content of FMSC-enriched mayonnaise exhibited a marked increase when compared to its synthetic counterpart. Moreover, the incremental addition (200–1000 ppm) of FMSC polyphenols exhibited a dose-dependent inhibition of free-radical formation in peanut oil, thereby forestalling oxidative rancidity and degradation in oils during both regular and accelerated storage periods of 7.8 weeks, respectively [3]. FMSC polyphenols demonstrated a noteworthy efficacy in reducing primary and secondary oxidation byproducts at concentrations of 800 and 1000 ppm in oils stored for a duration of up to three months.

Millet Waste as Diabetic Therapeutic Bakery Foods: Utilization of finger millet by-products in biscuits has the potential to offer inherent health advantages, such as calcium, iron, and zinc, to individuals. The escalating demand for functional foods has prompted the food industry to develop fiber-enriched products. This investigation delved into the rheological, microstructural, physicochemical, and functional attributes of whole proso millet dough and cake fortified with fermented proso millet bran dietary fiber flour (F-DF). Findings indicated that proso millet flour exhibited lower absorbency and stability compared to the control group. The addition of proso millet flour and F-DF decreased the dough's elasticity and increased its hardness, while not significantly impacting viscosity, cohesion, and resilience. Microscopic analysis revealed an irregular continuous network formation in proso millet dough. The analyses suggested that the amalgamation of proso millet flour with fermented dietary fiber significantly enhanced the total phenol content (0.46 GAE mg/g), DPPH• scavenging activity (66.84%), and ABTS•+ scavenging activity (87.01%) compared to the alternative group. Moreover, F-DF contributed to a notable decrease in the anticipated released glucose levels of reformulated cakes. In essence, cakes prepared with whole proso millet flour and F-DF exhibited minimal unfavorable sensory effects and demonstrated the potential to lower postprandial blood glucose levels solely from cake consumption [29].

Millet Waste as Therapeutic Fermented Foods: Proso millet bran (PB) represents a by-product of prosomillet processing, primarily composed of dietary fiber. Currently, due to its coarse taste and unfavorable flavor, PB is predominantly utilized in animal feed research and development, with some portions being discarded. Derived dietary fiber was designated as F-DF, from defatted proso millet bran (DPB) through lactobacillus fermentation. F-DF showcased several remarkable physicochemical properties, including exceptional water-holding capacity (WHC), oil-binding capacity (OHC), and water-swelling capacity (WS), along with valuable adsorption features like cholesterol, sodium cholate, and nitrous acid adsorption. Hence, it can be inferred that proso millet bran has the potential to serve as a fermentation enhancer and a specialty ingredient in fermented foods, thereby enhancing consumer acceptance [16].

Millet Waste as Therapeutic Oil: Foxtail millet bran oil is abundant in linoleic acid, constituting over 60% of its lipid composition. Ethyl linoleate (ELA) is a valuable compound commercially, known for its numerous beneficial health properties. The present study optimized two processing steps for ELA, namely urea complexation (UC) and molecular distillation (MD), through single-factor and response surface analyses. The primary objective of this research was to achieve a highly concentrated ELA within the limits permitted by existing regulations. The optimal conditions were determined as follows: an ethanol-to-urea ratio of 15:1 (w/w), urea-to-fatty acid ratio of 2.5:1 (w/w), crystallization time of 15 hours, and crystallization temperature of -6 °C. ELA concentration peaked at 45.06% under the optimal UC conditions. The ideal MD purification conditions were identified as a distillation temperature of 145 °C and a vacuum pressure ranging from 1.0 to 5.0 × 10-2 mbar, resulting in an increased ELA purity of 60.45%. The combined employment of UC and MD proved effective in enhancing the overall ELA concentration in the end product. This research highlights the optimal conditions for the isolation and purification of ELA from foxtail millet bran oil using UC and MD techniques [12].

Foxtail millet stands as one of the earliest cultivated cereal grains characterized by a diverse array of nutrients. Additionally, the milling process of foxtail millet gives rise to foxtail millet bran (FMB), which is also abundant in various essential nutrients. The categorization of FMB comprises four distinct classes: coarse bran (FMCB), skin bran (FMSB), polished bran (FMPB), and mixed bran (FMMB). The distribution of these nutrients varies across the different fractions of FMB. Research findings have demonstrated that the oil derived from FMB represents a high-value plant-based oil. Notably, this oil is rich in unsaturated fatty acids (UFAs), predominantly linoleic acid (65%~69%) and oleic acid (12~17%), constituting over 80% of the lipids present. The primary triacylglycerols identified were trilinolein (LLL) and oleodilinolein (OLL). While there were no discernible variations in the profiles of fatty acids, triacylglycerols, and sterols for FMSB, FMPB, and FMMB, differences were observed in the levels of amino acids, tocols, squalene, and oryzanol [15].

Millet small bran is a residual product derived from the processing of millet. It represents a cost-efficient option for obtaining nutritious oil, characterized by a 23% oil content and essential components such as 72% essential fatty acid, tocopherol, phytosterol, and oryzanol. The aqueous enzymatic extraction of oil from millet bran has garnered significant attention in recent years. Nonetheless, this technique is plagued by drawbacks including high production expenses, suboptimal extraction efficiency, and notable nutrient loss. To address these issues and enhance the nutritional value of the final products, researchers have devised the ethanol extraction method. This approach involves utilizing the response surface method (RSM) to fine-tune the extraction parameters. The study delves into the impact of extraction temperature, extraction duration, solid-liquid ratio, and ethanol concentration on the process. Findings indicate that extraction duration, solid-liquid ratio, and ethanol concentration play pivotal roles in bolstering the yield of free oil. By employing the box–behnken design principle, a response surface analysis incorporating 3 factors and 3 levels was conducted to optimize the extraction process.

The optimal conditions for this aqueous extraction method were determined as follows: extraction duration of 120 minutes, solid-liquid ratio of 1:5, and ethanol concentration of 30%. These conditions led to an oil yield of 89.216%. Evaluation of quality parameters like acidity, peroxide value, and water content of millet small bran oil extracted using an aqueous ethanol solution revealed that the quality of the oil surpassed the national standard for crude millet bran oil and closely resembled the first-grade pressed bran oil stipulated by the national standard. The tocopherol and phospholipid contents in millet small bran oil were measured at 131.32mg/100g and 1.12g/100g, respectively. The aqueous ethanol extraction method emerges as an effective technique for obtaining millet small bran oil while preserving nutrients like phospholipid and tocopherol to a significant degree. Consequently, it is evident that aqueous ethanol technology holds promising prospects for application within the oil production industry [9].

The chemical properties of a sample of foxtail millet bran and its oil, with a specific focus on the approximate composition of the bran, the fatty acid profile, as well as the physicochemical properties and tocopherol composition of the oil derived from foxtail millet bran. The findings reveal that the millet bran contained approximately 9.39 ± 0.17% crude oil, 12.48 ± 0.41% crude protein, and 51.69 ± 2.14% crude fiber. The tocopherol content was measured at 64.83 ± 0.83 mg/100 g of oil, primarily composed of γ-tocopherol at 48.79 ± 0.46 mg/100 g of oil, followed by α-tocopherol at 15.53 ± 0.31 mg/100 g of oil. Analysis showed that the millet bran oil exhibited high levels of linoleic acid at 66.5% and oleic acid at 13.0%. Furthermore, the saturated fatty acids identified included palmitic acid at 6.4% and stearic acid at 6.3%. Notably, linoleic acid was found to be the predominant fatty acid in the sn-2 position, constituting 71.2% of the millet oil. The principal triacylglycerols, as determined by the 1, 3 - random - 2 - random hypothesis, were trilinoleate (LLL) at 29.3% and dilinoleoyl-monoolein (LLO) at 17.2%. This study provides valuable insights for potential applications involving millet bran and its oil [11, 12].

CONCLUSION: Millet is consumed in the form of dehulled polished millet rice, whole millet flour, germinated millet flour, puffed millets and flaked millets. During primary and secondary processing tangible amount of waste is generated. Though considerable amount of research is being carried out to bring about zero processing wastes, it is still to be achieved. Therefore addressing millet processing waste is the need of the hour. Otherwise, disposal of millet processing waste will become a menace. The only alternative available is landfills, fodder, waste water treatment, fuel analogues and the like. But, these are also not commercially successful. Millet processing wastes includes husk and bran, brokens, sediment in beverage preparation, while unflaked millets and unpuffed millets during the process of flaking and puffing operations renders about 15-20 % and 30-50 % wastage respectively. Millet processing wastes are a rich source of phenolic compounds with antioxidant potential. The rice bran as potential source of dietary fibre, minerals and B vitamins has wide applications in the food and health industry. Millet bran is also a potential raw material for extraction of oil which is still untapped in food applications.

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CONFICT OF INTEREST: NIL

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