Developement of multimillet enriched value added product

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***Abstract*—**One of the under utilized group of cereals is millets. Almost one-third of the world's population is supported by millets, which also exhibit outstanding resistance to a variety of biotic and abiotic stresses. Millets are a rich source of protein, fatty acids, vitamins, minerals, dietary fibre, and polyphenols in addition to providing energy. The goal of this review is to investigate numerous morphological, biochemical, and molecular aspects of Millets' mechanism. Selected millets (Pearl millet, Sorghum finger millet, and Foxtail millet) had their physical, chemical, and functional qualities investigated. As compared to other millets, finger millet has a higher moisture content. When compared to other millets, pearl millet has a higher bulk density (1.75). All millets had a low fat level. Millets were found to have greater concentrations of calcium, iron, and phosphorus. Millets are a great source of dietary fibre,protein, vitamins, and minerals as per the literature. Therefor the efforts were made to develope a nutritious product as millets can be use as substitute for rice or other grains in many reciepes. 4 different millets were selected and formulated a most popular extruded product (Shev). Physical and chemical properties of product were evaluated which include macro and micro nutrients after processing. Shelflife study of packaged product were carried out in HDPE at room temperature by calculating its peroxide and acid value after every 8 days of interval.

***Keywords*—**Millets, Nutritious, Health benefits, Protein, Vitamins, Minerals, Sustainability, Food products, Physical properties, Functional properties

I. INTRODUCTION

In recent years, there has been a growing awareness and interest in the consumption of diverse and nutrient-rich foods to promote health and well-being. Among these, millets have gained considerable attention due to their nutritional value, resilience to adverse environmental conditions, and their potential to contribute to food security. Millets are small-seeded grasses widely cultivated and consumed as staple foods in many parts of the world, especially in Asia and Africa.

Despite their nutritional benefits, millets have often been overlooked in favor of other cereals such as rice, wheat, and maize. However, with increasing concerns about food security, sustainability, and health, there has been a resurgence of interest in millets as a versatile and sustainable alternative.

In this context, the development of multimillet enriched value-added products represents a promising avenue for enhancing the accessibility and appeal of millets to a broader consumer base. Value-added products are those that undergo some form of processing or enhancement to improve their nutritional profile, taste, shelf-life, or convenience. By incorporating multiple varieties of millets into these products, along with other nutritious ingredients, it is possible to create innovative and highly nutritious food options that cater to the diverse preferences and dietary needs of consumers.

This paper aims to explore the development of multimillet enriched value-added products, focusing on the potential health benefits, technological considerations, market opportunities, and challenges associated with their production and commercialization. Through a comprehensive analysis of existing research, industry trends, and case studies, we seek to highlight the importance of millets in promoting food security, nutrition, and sustainable agriculture, and to provide insights into the strategies for successfully incorporating millets into value-added food products.

II. MATERIALS AND METHOD

A. *Physical properties of millets*

I. Size and Shape (in terms of length, width, and thickness)

10 randomly chosen grains' were evaluated for the physical properties and given in the mm.

II. True Density:

50 ml of toluene was taken in a measuring jar. A known weight of grain sample was pouredto the measuring jar and rise in the toluene level was recorded. The true density of the grain was calculated by using the following formula [1].

$$True\ density, Kg/m3 = \frac{\text{Weight of grains (kg)}}{\text{Volume of grains excluding void space (m3)}}$$

III. Bulk density:

Bulk density was determined by using a container of known volume. The sample was takeninto the container for the known volume and weighed. The bulk density was determined using the formula [2].

$$Bulk\ \ density, Kg/m3 = \frac{\text{Weight of grains (kg)}}{\text{Volume of grains including pore space (m3)}}$$

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IV. Porosity

Porosity of sorghum grains was calculated from the bulk density and true density values (that were found earlier) by using the following formula [2]

$$Porosity,\% = 1 - \frac{\text{Bulk density(kg)}}{\text{True Density (m3)}} * 100$$

B. Chemical properties of millets

I. Moisture Content:
The most common method for determining moisture content is the oven-drying method. In this method, a known weight of the sample is dried in an oven at a specific temperature (usually around 105°C) until a constant weight is achieved.
Calculation: Moisture content (%) = ((Initial weight - Final weight) / Initial weight) x 100 [3]

II. Ash Content:
Ash content is determined by burning a known weight of the sample at high temperature until complete ashing. The ash remaining represents the inorganic mineral content of the sample.
Calculation: Ash content (%) = (Weight of ash / Weight of sample) x 100

III. Crude Protein:
To determine the protein content present in raw material, Kjeldahl method is used. Here, the sample is digested with sulfuric acid to convert nitrogen into ammonium sulfate, which is then distilled and titrated to determine the nitrogen content. Crude protein is calculated by multiplying the nitrogen content by a conversion factor (typically 6.25 for most food products). [3]
Calculation: Crude protein (%) = (Nitrogen content x Conversion factor) / Weight of sample

IV. Crude Fat (or Lipid):
The Soxhlet extraction method is commonly used to determine crude fat content. In this method, the sample is repeatedly extracted with a solvent (e.g., petroleum ether) to remove lipids. The solvent is then evaporated, and the remaining fat is weighed [3].
Calculation: Crude fat (%) = (Weight of fat / Weight of sample) x 100

V. Crude Fiber:
Crude fiber content is determined using a series of chemical treatments to remove soluble carbohydrates, proteins, and lipids, leaving behind the indigestible fiber fraction. This method involves acid and alkaline digestion followed by filtration and drying [3].
Calculation: Crude fiber (%) = (Weight of residue / Weight of sample) x 100

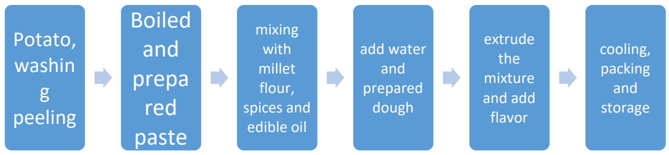
VI. Carbohydrates are typically calculated by difference, subtracting the sum of moisture, ash, protein, fat, and fiber from 100%.
Calculation: Carbohydrates (%) = 100 - (% Moisture + % Ash + % Protein + % Fat + % Fiber)
Table

Table 1. Optimization of product formulation

Sr. No	Ingredients	T1	T2	T3	T4
1	Sorghum flour	20	30	40	50
2	Pearl millet flour	40	30	20	10
3	Finger millet flour	08	06	04	02
4	Foxtail millet flour	02	04	06	08
5	Potato flour	30	30	30	30

Common ingredient with same proportion: Red chilli powder: 4%, Salt: 2%, Turmeric: 1%, Ajwain: 0.5%, Water: 50 ml.

C. Development of multimillet Bhujia



D. Sensory evaluation and chemical profiling of multi-millet bhujia

Optimization of formulated product was done using 9 point hedonic scale and further it is evaluated for its chemical and nutritional fact.

E. Storage studies and packaging

Shelf life studies were carried out for 2 months and quality were evaluated by calculating the peroxide value after 8 days interval. Peroxide value (PV) is a measure of the extent of oxidation of lipids or fats in a sample. It is commonly used to assess the freshness and oxidative stability of oils and fats, including those extracted from millets.

I. Peroxide value:

4 to 5 gm of sample is accurately weighed into dried 250 ml flask. To that , 25 ml of solvent (mix 2 volumes of glacial acetic acid and 1 volume of chloroform) is added and mixed homogeneously. 1ml of potassium iodide solution is added and allowed to stand in dark for 1 minute. After 1 min, 1 ml distilled water and 1 ml starch indicator was added and titrate against 0.002N sodium thio sulphate from 10ml volumetric burette. End point is disappearance of blue colour, peroxide value was determined using following formula

$$peroxidevalue = \frac{1000 * 0.01(normalityofthiosulphate) * titrevalue}{weightofSample}$$

III.RESULT AND DISCUSSION

a. Physical properties: Physical properties of millets were carried out to check the milling properties of raw material for the application. Table 2 indicates the physical properties of different millets used for processing.

Table 2. Physical properties of different millets for product development

Raw Material	Length	Thickness	Bulk density	True density	Porosity
Pearl millet	3.6mm	2.1mm	8512.5 kg/ m3	1265.1 kg/ m3	32.8 %
Finger millet	1.5mm	1.4mm	711kg/ m3	1125 kg/ m3	29.7 %
Foxtail millet	2.2mm	1.5mm	734.8kg/ m3	1265.7 kg/ m3	40.8 %
Sorghum	4.2mm	2.5mm	811.3kg/ m3	1447.2 kg/ m3	55.2 %

The grains vary significantly in size (length and thickness), which affects how they are processed and their physical handling characteristics. These dimensions can influence various properties such as packing density and processing efficiency. Finger millet has the lowest bulk density, indicating it occupies more volume for a given mass compared to the other grains. Sorghum has the highest true density, suggesting it has denser material composition per unit volume. Sorghum exhibits the highest porosity among the grains listed, meaning it has a higher proportion of air gaps or void spaces within its structure compared to the others. These parameters are crucial for various applications such as food processing, storage, transportation efficiency, and nutritional studies. The differences observed reflect the diverse physical properties of these grains, which influence their behavior in different contexts, from agricultural production to industrial processing and consumer use. The results ar in line with the previous authors [1,2]

b. Chemical Properties:

Chemical analysis (Table 3) of the mentioned raw material were carried out to check the nutritional goodness of the raw material. The obtained results were indicated in Table.3.

Table 3. Chemical analysis of selected millets

Chemical content	Pearl millet	Finger millet	Foxtail millet	Sorghum
Moisture (%)	16	20	13	11
Fat (%)	4.86	1.8	2.38	1.6
Ash (%)	1.64	2.7	0.47	1.4
Protein (%)	14.8	8.2	11.50	9.47
Fibre (%)	12.19	3.5	NA	10.2
carbohydrates	59.08	83.03	75.02	66.2

Moisture content is an important parameter as it affects the stability and shelf life of grains. Higher moisture content can lead to quicker spoilage if not stored properly. In this case, finger millet has the highest moisture content, which may require more careful handling during storage and processing. Fat content indicates the lipid content in the grains. Pearl millet has the highest fat content among the grains listed, which could be significant depending on dietary considerations and also influence its applications in cooking or processing, especially in regions where oil extraction is significant (Table 3.). Ash content represents the mineral content of the grains after complete combustion. Finger millet has the highest ash content, suggesting it contains more minerals compared to the other grains listed. Pearl millet has the highest protein content, followed by foxtail millet. Finger millet, while still a good source of protein, has a lower percentage compared to the others. Finger millet has the highest carbohydrate content, followed closely by foxtail millet. Each grain offers a unique nutritional profile. Pearl millet stands out with higher protein and fibre content, making it potentially more *satiating* and nutritious. Finger millet is notably higher in carbohydrates, which could be advantageous for energy requirements [4,5].

c. Nutritional properties of finished product: The prepared product were evaluated for its chemical /nutritional content to check the storage stability of product during storage. Also it is mandatory to provide all the information on the label as well.

Table 4. Nutritional components of multimillet Product (Bhujia) .

Sr. No	Chemical component	Content
1.	Protein (g)	7.93
2.	Carbohydrates (g)	51.85
3.	Energy (Kcal)	548.99
4.	Cholesterol (mg)	< 0.5
5.	Total sugar (g)	2.18
6.	Added sugar (g)	<0.5
7.	Sodium (mg)	496.30
8.	Total fat (g)	34.43
9.	Trans fat (g)	0.003
10.	Saturated fat (g)	3.47
11.	Unsaturated fat (g)	30.96

d. Storage study:

considering the nutritional factors and since it is fried product, the analysis of acidity and peroxide value was done. Obtained results were indicated in the Table 5. Acidity levels appear relatively stable across the samples over time, with minor fluctuations within a narrow range (0.37 to 0.39). This suggests that the product is maintaining its acidity within acceptable limits, indicating good quality control in terms of processing or storage conditions. To maintain the quality of product, acidity is an important parameter in monitoring the freshness and spoilage of food products. The slight increase in acidity in Sample5 after 2 months could indicate a slight deterioration, although the overall change is minimal.

Table 5. Storage study at room temperature (32℃)

Parameter/Days	8	16	24	32	40
Acidity (%)	0.37	0.37	0.38	0.37	0.39
Peroxide Value (%)	2.6	2.7	2.7	2.9	3.0

Peroxide value is a measure of primary oxidation products in fats and oils, indicating their freshness and potential for rancidity. The peroxide values show a gradual increase over time, which is expected as oils and fats undergo oxidation reactions. The values (2.6 to 3.0 meq/kg) are within typical ranges for edible oils and fats. The increase in peroxide value indicates the accumulation of oxidative products, which can affect the flavor, aroma, and nutritional quality of the product. Sample5 showing the highest peroxide value after 45 days suggests a more advanced stage of oxidation compared to earlier samples [6]. These results suggest that the product is reasonably stable over the monitored period. However, continuous monitoring is important to ensure quality is maintained, especially considering the slight increases in acidity and peroxide value.

IV.CONCLUSION

Millets are recognized for their abundant dietary fiber, protein, vitamins, and minerals, as documented in the literature. Therefore, efforts were directed towards developing a nutritious product that could serve as a viable substitute for rice and other grains in various recipes. As a popular choice, Shev, an extruded product, was formulated using four different millets. The physical and chemical properties of the Shev product were extensively evaluated, encompassing macro and micronutrient analysis post-processing. Additionally, a shelf-life study was conducted under ambient conditions using HDPE packaging, monitoring peroxide and acid values at regular intervals of 8 days. This comprehensive investigation underscores the potential of millets not only as a staple food but also as a versatile ingredient for developing value-added products. The findings contribute valuable insights into enhancing the nutritional diversity of diets and promoting sustainable agricultural practices.

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References

[1] Barveh F.A. Physical properties of millet. *J Food Eng.* 2002;51, pp. 39–46..

[2] Dutta S.K., Nema V.K., Bhardwaj R.K. Physical properties of gram. *J Agric Eng Res.* 1988, 39, pp 259–268.

[3] AOAC. Official methods of analysis, Association of official analytical chemistry. Washington, D.C. U.S.A, 2005, 18th Ed.

[4] Veena B, Chimmad BV, Naik RK, Shantakumar G. Physico-chemical and nutritional studies in barnyard millet. Karnataka Journal of Agricultural Science. 2005; 18(1):101–05

[5] Hadimani , N.A. , Ali , S.Z. and Malleshi , N.G. 1995 . Physicochemical Composition and Processing Characteristics of Pearl Millet Varieties . *Journal of Food Science and Technology* , 32 (3) : 193 – 198 .

[6] V.G Lende, M.G Jarhad, K.B Nehe, G.B Mite., Formulation of Nutrients Rich Multigrain Sev and It's Storage Potential, IJIRT. 2022, vol.9, issue 5.

[7] Singson H, Shradda GS, Nirmala B, Yenagi ST. Documentation of chakali recipies and evaluation of commercial chakali for physico-chemical and sensory attributes. Karnataka J. Agric. Sci. 2014, 27, pp. 208- 212.