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Development of Low GI – Protein Rich Millet – Pulse Instant Porridge

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Abstract- Growing demand for nutritionally balanced foods with a low glycemic response and improved micronutrient density has emerged due to the rising prevalence of lifestyle-related disorders such as diabetes and iron-deficiency anemia. Millets are recognized for their high dietary fiber content, slowly digestible carbohydrates, and rich mineral profile, which provide substantial potential for the development of functional foods. However, limitations associated with protein quality and consumer convenience highlight the need for improved product formulation. The present study focused on the development of a low glycemic index, protein and iron-enriched instant porridge using selected millets and pulses. Millets were blended with pulse flours to enhance overall protein quality and improve mineral bioavailability, while suitable processing techniques were applied to obtain an instant, shelf-stable product. The developed porridge mix was evaluated for proximate composition, dietary fiber, protein and iron content, sensory acceptability, and glycemic index. Results demonstrated that the millet–pulse based porridge contained appreciable levels of protein and iron along with high dietary fiber, contributing to a reduced glycemic response. Sensory evaluation showed acceptable scores for appearance, texture, taste, and overall acceptability, indicating good consumer potential. The low glycemic index of the developed product supports its suitability for individuals with impaired glucose tolerance, diabetic conditions, and health-conscious populations. The research results show that millet and pulse combinations can be used to create instant foods that provide better nutrition and solve health problems related metabolic disorders and micronutrient deficiencies.

Keywords: *Low Glycemic Index, Millets, Pulses, Instant Porridge, Protein Enrichment, Iron Fortification, Dietary Fibre, Functional Foods, Glycemic Response, Convenience Foods.*

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I. INTRODUCTION

Health mix powders are a combination of cereals, pulses, and functional ingredients having a scientific formulation, and they are made to supply balanced nutrition in a convenient and easily consumable manner. Because of the rising awareness of preventive healthcare and diet-related diseases, health mixes have become more popular as nutritious replacements for refined and highly processed foods [1]. The developed formulations aim to deliver adequate energy, protein, dietary fibre, and essential micronutrients. While having a low glycemic response, thus making them suitable for people of all ages including those with metabolic disorders [2].

Millets are recognized as the best cereals from nutritional point of view because of their very good properties such as high dietary fiber, starch that is slowly digestible, important minerals and bioactive compounds. Eating millet-based products regularly has been linked to better blood sugar control, increased feeling of fullness and lowered risk of diabetes mellitus type-2 [3]. Proso millet or *Panicum miliaceum L.* is a member of the family *Poaceae* and is one of the oldest domesticated millets that originated in Central Asia. It should have moderate protein content, and of good digestibility, and should have low glycemic potential [4]. Pearl millet or *Pennisetum glaucum L.*, which is also a *Poaceae* family member and could be traced back to Africa, is mainly known for its high iron, zinc and dietary fiber contents and has been associated with significant advancements in glycemic and micronutrient management [5].

Even though millets have nutritional benefits, they are still regarded as being less advantageous due to lower protein quality which is caused by the lack of an essential amino acid, lysine. The combination of cereals and pulses can come in handy for this limitation to be solved. Besides, pulses contain a good amount of plant-based protein, minerals, dietary fibre, and bioactive compounds which

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together make the nutritional balance of cereal-based foods more favorable [6]. Red kidney beans (*Phaseolus vulgaris L.*) originate from Central and South America and belong to the *Fabaceae* family because they provide both nutritional benefits and delicious taste together with their high protein content and iron content and their complex carbohydrate content [7]. Moreover, the studies done on the addition of pulses in the making of cereal products revealed that the digestibility of starch is reduced and the glycemic index lowered due to the increased interactions of fibre and protein [8].

Traditional food processing practices in food technology have long utilized millet–pulse composite flours and health mix formulations to enhance nutritional quality and functional properties. Previous studies have reported that processing techniques such as roasting, germination, extrusion, and drying not only improve nutrient bioavailability but also reduce anti-nutritional factors, thereby enhancing the sensory acceptability of millet–pulse-based products [9,10]. The use of such composite flours has facilitated the development of instant porridge products, offering advantages such as reduced cooking time, ease of preparation, extended shelf life, and ready-to-eat convenience. These attributes make instant millet–pulse porridges particularly suitable for urban consumers as well as nutritionally vulnerable populations [11].

The glycemic index (GI) in an essential way is a metabolic indicator that used to categorize firstly, carbohydrate-rich foods and lastly, their post-consumption effect on the blood glucose level. Low-GI foods consumption is linked to various health improvements, including better insulin sensitivity, and less oxidative stress and development of long-term metabolic diseases being less likely to happen [12]. Millet-based hot cereals, on the other hand, and composite food formulations fall generally into the low- to medium-GI category compared with the conventional rice- and wheat-based products; hence, they are commonly recommended for people suffering from diabetes or with impaired glucose tolerance [13–15]. Besides this, millets and pulses are considered to be rich in dietary fiber that is non-digestible, resistant starch, and phenolic compounds thus they are believed to have similar antioxidant properties and to play a role in the improvement of metabolic processes besides their consumption [16].

Thus, the formulation of an instant porridge with low glycemic index, high protein and iron using millets and pulses can be regarded as a strong dietary measure against protein-energy malnutrition, iron deficiency anemia, and metabolic disorders induced by lifestyle. These functional health mix products not only enhance the utilization of millets which are underexploited but also, through value addition, sustain nutritional security and food systems that are environmental friendly [17–20].

II. MATERIALS AND METHODS

➢ *Selection and Procurement of Raw Materials:*

The selection of proso millet (*Panicum miliaceum L.*), pearl millet (*Pennisetum glaucum L.*), and red kidney beans (*Phaseolus vulgaris L.*) as the main raw materials was made on the basis of their nutritional and functional characteristics. The local agricultural markets were the sources of the raw materials for the purpose of freshness and availability. Before processing, all grains were subjected to manual inspection to eliminate foreign matter, broken kernels and damaged seeds.

➢ *Pre-Processing of Millets and Pulses:*

The cleansing process of millet and bean, carried out in the first instance of the pre-processing operation, rendered the selected millets and red kidney beans extra clean by washing them meticulously with potable water and then drying them in the shade. The roasting of the dried grains was done separately under controlled conditions with the aim of improving the flavour, digestibility, and the reduction of the anti-nutritional factors. The cooling of the roasted grains to room temperature, milling them into fine flour using a laboratory grinder, and sieving to obtain uniform particle size were the next steps of the process. The flours were stored in airtight containers until the next processing stage.

➢ *Millet–Pulse Instant Porridge Mix formulation:*

Proso millet flour, pearl millet flour, and red kidney bean flour were varied in their proportions to develop four distinct formulations (F1, F2, F3, and F4). The compositions were aimed at increasing the content of protein and iron while keeping the glycemic index low. The accurate amounts of the different flours were mixed uniformly to produce the instantly cooked porridge mixes of the same quality. The Table 1 formulation of porridge as shown below

Table 1: Formulation of Protein-Rich Millet–Pulse Instant Porridge

PARAMETERS	F1 (Good)	F2 (Better)	F3 (Very Good)	F4 (Best)
PROSO MILLET (%)	35	30	25	25
PEARL MILLET (%)	35	30	25	40
RED KIDNEY BEANS (%)	30	40	50	35

➢ *Formulation and Preparation of Millet–Pulse Based Instant Porridge:*

The instant porridge mix was produced by mixing up various proportions of proso millet flour, pearl millet flour, and red kidney bean flour to increase the nutritional value and at the same time, the sensory quality was not compromised. Four different mixtures were made and labeled F1, F2, F3, and F4; they differed from each other in the amount of millet and pulse flours used. The main idea behind these blends was to improve the protein and iron content and at the same time to obtain a lower glycemic effect.

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Each flour ingredient was accurately weighed based on the determined formulation ratios and mixed very well to make sure the ingredients were evenly distributed. The product was made without using any synthetic additives or preservatives. The dried heat treatment was utilized for the blended composite flour based on rapid hydration and reconstitution properties. The Fig 1 formulation of instant porridge as shown below

Fig 1 Formulation of Instant Porridge

The instant porridge mixes were then cooled down to room temperature and stored in airtight, moisture-proof containers which helped to maintain their quality and shelf stability. The prepared formulations underwent nutritional analysis, glycemic index assessment, and sensory testings. A visual representation of various millet–pulse instant porridge formulations developed in the current research has been provided.

All the flour components were accurately weighed as per the stipulated formulation ratios and then mixed very well so that every ingredient was evenly distributed. The product was prepared without using any synthetic additives or preservatives. The Fig 2 formulation varieties as shown below

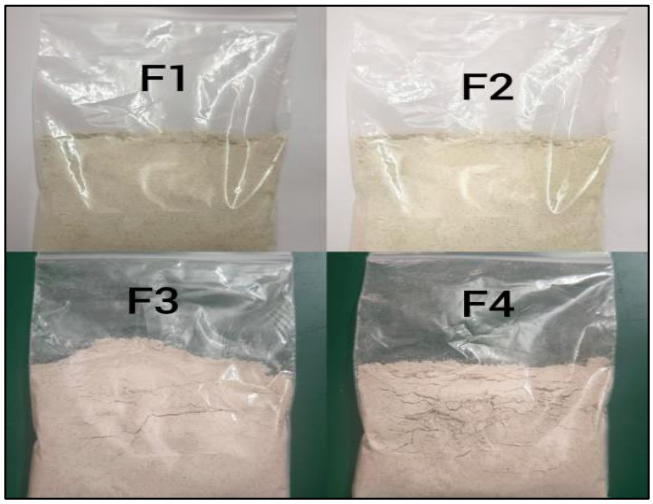

Fig 2 Formulation Varieties

➢ *Preparation and Processing of Millet–Pulse Based Instant Porridge Mix:*

The raw materials used in this study included proso millet (*Panicum miliaceum L.*), pearl millet (*Pennisetum glaucum L.*), and red kidney beans (*Phaseolus vulgaris L.*). The initial step was the cleaning process, which was done to rid the materials of foreign matter like stones, dust, chaff, and damaged grains. The grains were cleaned, then thoroughly washed with potable water and shade-dried in order to decrease surface moisture.

The dried millets and pulses were then roasted separately under controlled conditions and this roasting was mainly for the purpose of the enhancement of the flavor, the improvement of the digestion, and the reduction of the anti-nutritional factors. The cooling took place immediately after the roasting when the grains were allowed to get to the ambient temperature. The next step was grinding and the roasted samples were put through the laboratory-scale grinder to get the fine flour.

The sieving of the obtained flours was done using the standard mesh sieve, to make sure of the uniformity of the particle size distribution. Particle size consistency is important for uniform reconstitution and it also depends on the texture of the instant porridge. The sieved flours were weighed accurately according to the formulation ratios.

The four different composite formulations resulted from blending proso millet, pearl millet, and red kidney bean flour in predetermined proportions. The weighed flours were rigorously mixed to get a homogeneous composite flour blend. Then the formulated mixes were treated with dry heat to get the improvement of the instantization characteristics.

The final mixes of the instant porridge were subjected to cooling and packed into the airtight moisture-proof containers to prevent the absorption of moisture and to ensure the product quality. The process of the prepare.

Each particular flour component was weighed with precision according to the formulation ratios specified and it was then thoroughly mixed together so that there would be a homogeneous distribution of the ingredients. The product was prepared without the addition of synthetic additives or preservatives.

➢ *Processing Method for Instantiation:*

The prepared composite flours were put through dry heat treatment to better the properties of instant reconstitution. This procedure raised the water absorption capacity, and the cooking time was lessened. The mixes that had been processed were cooled down, packed in containers that prevented moisture and then stored at room temperature for the analysis that was to follow.

➢ *Nutritional Analysis (Proximate Composition):*

The instant porridge formulations were subjected to proximate composition analysis to determine their moisture, crude protein, and crude fat, ash, and carbohydrate contents

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according to standard AOAC methods. The carbohydrate content was determined by difference.

➢ *Determination of Iron and Protein Content:*

The protein amount in the porridge mixes was measured through Kjeldahl method. The iron level was determined either with a standard colorimetric method or atomic absorption spectrophotometry (AAS), and the findings were stated as mg per 100 g of sample.

➢ *Estimation of Dietary Fiber:*

The total dietary fiber content was determined by means of an enzymatic–gravimetric analytical technique. In this method, thick and thin fiber fractions were measured impartially and their values were shown as g per 100 g of sample.

➢ *Glycemic Index Evaluation:*

The estimations of the glycemic index of the formulated products were achieved through an in vitro starch digestibility method. The quantification of glucose liberation in the course of simulated digestion was performed and the predicted values of glycemic index were computed to rank the porridge as low, medium, or high GI food.

➢ *Sensory Evaluation:*

A semi-trained panel performed sensory evaluation of the reconstituted porridge samples with the help of a 9-point hedonic scale. The characteristics like appearance, colour, texture, taste, flavour and overall acceptability were assessed to select the most preferred formulation.

➢ *Statistical Analysis:*

All experiments were carried out in duplicates, and the outcomes were represented as mean ± standard deviation. The data were subjected to appropriate statistical tools for performing statistical analysis and for determining significant differences among the formulations. The Flow chart 1 the preparation process of protein-rich millet–pulse instant porridge as shown below

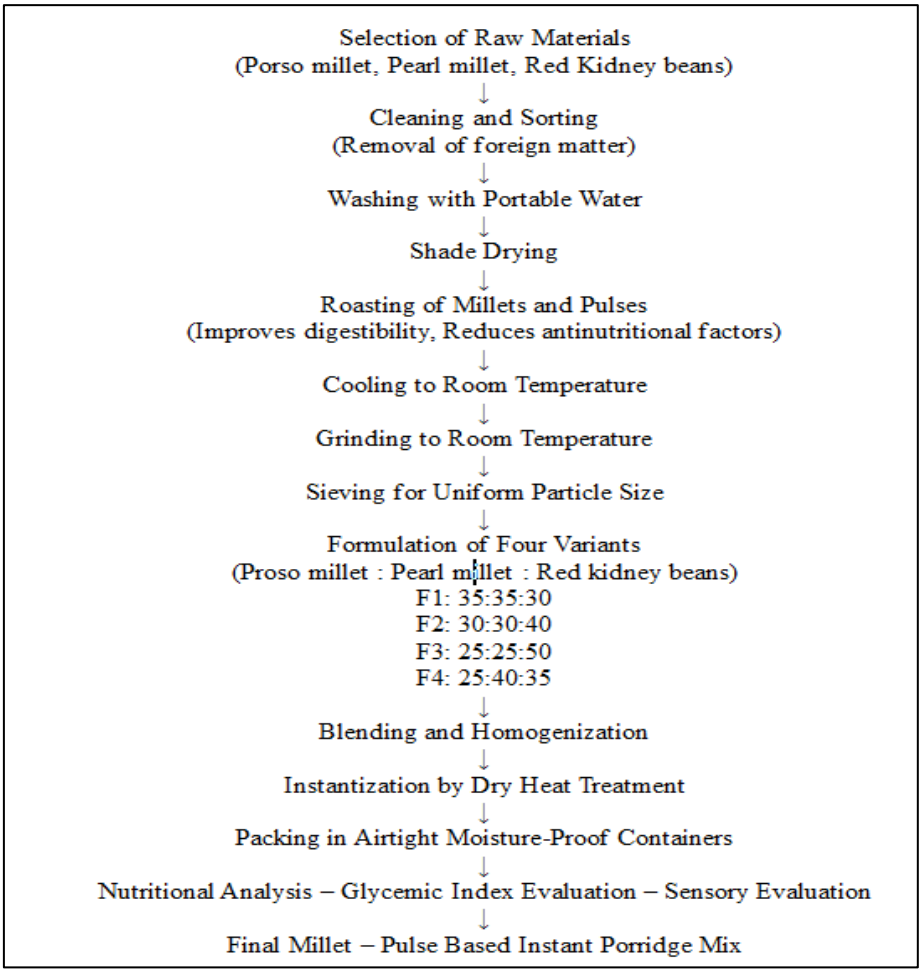

Fig 3 Flow Chart of the Preparation Process of Protein-Rich Millet–Pulse Instant Porridge

III. METHODOLOGY

➢ *Nutritional Composition of Developed Porridge Mix*

The newly made instant porridge mixes with millet and pulse base had a more nutritionally rich profile than conventional cereals. The combination of proso millet, pearl millet, and red kidney bean flour made positive changes in the protein, dietary fiber, and mineral contents of the product. The study of the food components showed a good distribution of the three main nutrients and thus the new

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product was considered a functional health mix. Its low fat with high complex carbohydrate fraction was another reason to support its regular consumption. The Table 2 nutritional characteristics of protein-rich millet–pulse instant porridge as shown below

Table 2 Nutritional Characteristics of Protein-Rich Millet–Pulse Instant Porridge

NURITIONAL INFORMATION		
Sl.NO	**PARAMETER**	**RESULT**
01.	Energy	367Kcal
02.	Protein	18.7gm/100gm
03.	Fat	2.9gm/100gm
04.	Carbohydrates	66.4gm/100gm
05.	Fibre	8.3gm/100gm
06.	Total Iron Content	5.7mg/100gm

➢ *Protein and Iron Enhancement through Pulse Incorporation*

The addition of red kidney bean flour led to a remarkable increase in the protein and iron content of the porridge formulations. Pulses are known for their excellent plant protein and iron that can be easily absorbed by the body. The gradual increase of pulses in the mix from 0% to 40% was directly associated with the increase of protein and iron levels thus showing the success of millet-pulse complementation in playing a vital role in overcoming the protein and micronutrient deficiencies.

➢ *Effect of Processing on Glycemic Index*

The application of different technologies like roasting, milling, and dry heat instantization significantly impacted the glycemic index of the produced porridge mixes. Besides, the mixture of dietary fiber, resistant starch, and protein coming from millets and pulses resulted in the reduced digestibility of starch. The estimated glycemic index values of the newly formed products were not only lower but also indicated the potential of being used in metabolic health management and glycemic control, comparing with traditional cereal-based porridges.

➢ *Sensory Acceptability of Instant Porridge*

Through sensory evaluation it was revealed that all the different formulations were acceptable, although differences were noticeable in color, texture, flavor and overall acceptability. The formulations with millet and pulse in a balanced ratio got better sensorial scores, as their mouth feel and flavor had developed during roasting. The findings suggest that the nutritional upgrade did not have a negative impact on the consumer acceptance of the instant porridge. The Table 3 chemical quality parameters of protein-rich millet–pulse instant porridge as shown below

Table 3 Chemical Quality Parameters of Protein–Rich Millet–Pulse Instant Porridge

CHEMICAL ANALYSIS		
Sl.NO	**PARAMETER**	**RESULT**
01.	Ash	2.1%
02.	Moisture Content	9.9%
03.	Water Absorption Capacity	2.7gm/gm
04.	Bulk Density	0.70gm/ml

➢ *Comparison with Conventional Cereal-Based Porridges*

In a head-to-head comparison with conventional cereal-based porridges, the instant porridge made from millet and pulse flour was found to be nutritionally superior especially in the aspects of protein, iron and dietary fibre. Also, the predicted glycemic index, which is lower than that of the cereals, along with the increased functional properties strengthens the argument of the developed porridge being a healthier option over refined cereal products. The research confirms the possibility of millet and pulse combining in developing value-added functional foods. The Table 4 qualitative phytochemical analysis of protein-rich millet–pulse instant porridge as shown below

Table 4 Qualitative Phytochemical Analysis of Protein–Rich Millet–Pulse Instant Porridge

PHYTO CHEMICAL ANALYSIS		
Sl.NO	**PARAMETER**	**RESULT**
01.	Phytic Acid	1.8mg/gm
02.	Tannic Acid	2.4mg/gm

IV. CONCLUSION

Through the accomplishment of the current research, a nutrient-dense instant porridge mix was posited and evaluated that had proso millet, pearl millet, and red kidney beans as the major components in different ratios. The protein and iron content of the developed formulations was significantly improved due to the inclusion of pulses, thus, confirming the efficaciousness of millet-pulse complementation in the aspect of nutritional quality.

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Moreover, the processing techniques employed, that is cleaning, drying, grinding, sieving, and instantiation, along with the development of functional properties, which were characterized by desirable bulk density, water absorption capacity, and reconstitution characteristics, contributed to enhancing the intrinsic quality of the instant porridge mix.

The formulation that was optimized, among the formulations explored, was characterized by the highest nutritional value, the lowest glycemic index, and improved acceptance of taste in terms of color, smell, taste, mouth feel, and total.

The decrease in glycemic index provides evidence of the product's suitability for the individuals with glycemic control needs. Assessment of shelf-life showed that the porridge powder had good storage stability under airtight conditions at room temperature with only minor changes in physicochemical and sensory properties.

The research concludes that an instant porridge based on millet and enriched with pulses can be a functional, economically viable, and nutritionally sound food product. Thus, there is a huge possibility for it to solve the problem of protein-energy malnutrition and to enhance the consumption of neglected millets by including them in convenient food formulations.

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