Title:
Development and Nutritional Evaluation of a Protein-Rich Health Supplement from Millets, Cereals, and Pulses.

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Abstract:
Millets are the group of highly variable small seeded grasses grown around the world as a cereal crop, recognised for their high nutritional values and their potential to addresses protein and micro nutrients deficiencies and they are known for gluten free, low glycaemic index these properties which help to prevent life style diseases. Mixing of millets and pulses improve the biological value of protein and complement greatly in filling the protein gap in the vegetarian diet. The present study aims to develop and evaluate the protein rich health supplement based on millets, cereals and pulses. Two formulations using different compositions are made viz minor millets with dhals and horse gram (P1) and Major millets, cereals, dhals and soyabean (P2). These formulations were analysed for proximate composition including moisture, ash carbohydrates, fats, protein and fiber content using standard analytical methods, and also sensory evaluation is carried for P1, P2 and Control using 9-point hedonic scale for attributes such as colour, flavour, texture, taste and acceptability. The overall acceptability of the products and control is statistically analysed by one way ANOVA with probability factor <0.05. Result reveal that P1 is more acceptable compare to other formulations. Hence millet and pulse-based health supplements can serve as nutritionally superior and acceptable food products, promoting utilization of millets, contributing to improve dietary protein and nutritional security.

Key words

Major millets, Minor millets, protein rich, health supplement, dietary fibre

Introduction

Millets are the group of highly variable small seeded grasses, widely grown around the world as cereal crops or grains for fodder and human body (Dayakar Rao *et al*,2017)

"Millet" is a common term to categorize small-seeded grasses that are often termed nutri- cereals or dryland-cereals. Millets are round-shaped cereal seeds, naturally available in many colours and sizes, depending on the variety. These are predominantly grown in semi-arid tropics of Asia and Africa. (k Lokesh *et al.,* 2022)

Millets belongs to the family Poaceae and consists of several species including pearl millet (*Pennisetum glaucum*), foxtail millet (Setaria *italica*), proso millet (*Panicum miliaceum*), fingermillet (*Eleusine coracana*), kodo millet (*Paspalum setaceum*), little millet (Panicum *sumatrense*), and barnyardmillet (*Echinochloa utilis*)

Millets are broadly classified into two categories: Major millets- Sorghum, Pearl millet.
Minor millets- Finger millet and small millets (Barnyard, Kodo, Foxtail, Little, Proso).

Millets are rich in macro nutrients and micronutrients, carbohydrates, proteins, dietary fibers, important fatty acids, and a vast number of minerals and vitamins. Millet carbohydrates have less starch compared to the other cereal crops. Millet dietary fibers act as prebiotics that help in the development of healthy gut microbiota. (M Gupta *et al* 2023)

International Crop Research Institute for Semi Aried Tropics (ICRISAT) has conducted extensive long research on millets, positioning them as a smart food and also instrumental in the nutritional profiling, bio fortification and promotion of millets as a Nutri – cereal to combat malnutrition and life style diseases. ICRISAT'S research highlights that millets are superior to staple cereals like rice and wheat in terms of essential minerals, dietary fibre, protein content and amino acid balance. (ICRISAT)

Pulses belong to the family of Leguminosae are important source of protein in the vegetarian diet they provide 20-25% of protein compare to cereals. As per the report Food and Agriculture organisation (FAO)Cereals and millet protein is in deficient in lysine rich in methionine where as pulses are rich in lysine and deficient in methionine hence mixture of cereals and pulses helps to improve protein quality and biological value. (shrilakshmi)

In this study a protein rich health mix is developed by using millets, cereals and pulses which will help in fulfilling the nutrition gap in the vegetarian diet. The nutritional composition of the millets and pulses are given in table 1.

Table 1. Nutritive Value of Millets and Pulses Used in The Formula.

Ingredients	Protein (gm)	Carbohydrates (gm)	Fat (gm)	Fibre (gm)	Energy (Kcal)	Iron (mg)	Calcium (mg)
Sorghum	10.4	70.7	3.1	2.0	353	4.1	25
Pearl millet	8.5	58	2.7	2.6	290	8	42
Finger millet	7.3	72	1.3	3.6	328	3.9	344
Barnyard millet	6.2	65.5	2.2	9.8	306	15.2	11
Kodo Millet	8.3	65.9	1.4	9.0	309	0.5	27
Foxtail millet	11.2	63.2	4	6.7	331	2.8	31
Little millet	7.7	67	4.7	7.6	341	9.3	17
Proso millet	12.5	70.4	3.1	7.2	358	0.8	14
Maize	9.2	73	4.6	2.8	370	2.7	10
Rice	6.8	72.8	0.5	0.2	345	0.7	10
Red gram dhal	22.3	57.6	1.7	1.5	335	2.7	73
Bengalgram Dhal	20.8	59.8	5.6	1.2	372	5.3	56
Green gram dhal	24.5	59.9	1.2	0.8	348	3.9	75
Black gram dhal	24.0	59.6	1.4	0.9	347	3.8	154
Soyabean	43.2	20.9	19.5	3.7	432	10.4	240
Horse gram	22.0	57.2	0.5	5.3	321	6.77	287

(Source: Indian Food composition table and Nutritive value of Indian foods, 2017 NIN Hyderabad)

Material and Methods

All the main raw materials are collected from the local market of Kalburagi city. The composition of materials used in products (P1 and P2) are given in Table 2.

Table 2: Composition of P1 and P1

P1 Minor Millets with Horse gram	P2 Major millets /cereal with soyabean
Foxtail millet	Sorghum
Little millets	Pearl millet
Kodo millet	Finger millet

Barnyard millet	Maize
Proso millet	Rice
Bengal gram dhal	Bengal gram dhal
Green gram dhal	Green gram dhal
Black gram dhal	Black gram dhal
Red gram dhal	Red gram dhal
Horse gram	Soyabean
All ingredients in both formulations are taken 1:1 proportion	

Preparation of Formula

Two products are prepared by using above ingredients, product 1: Major millets with four Dhals and Soyabeans.

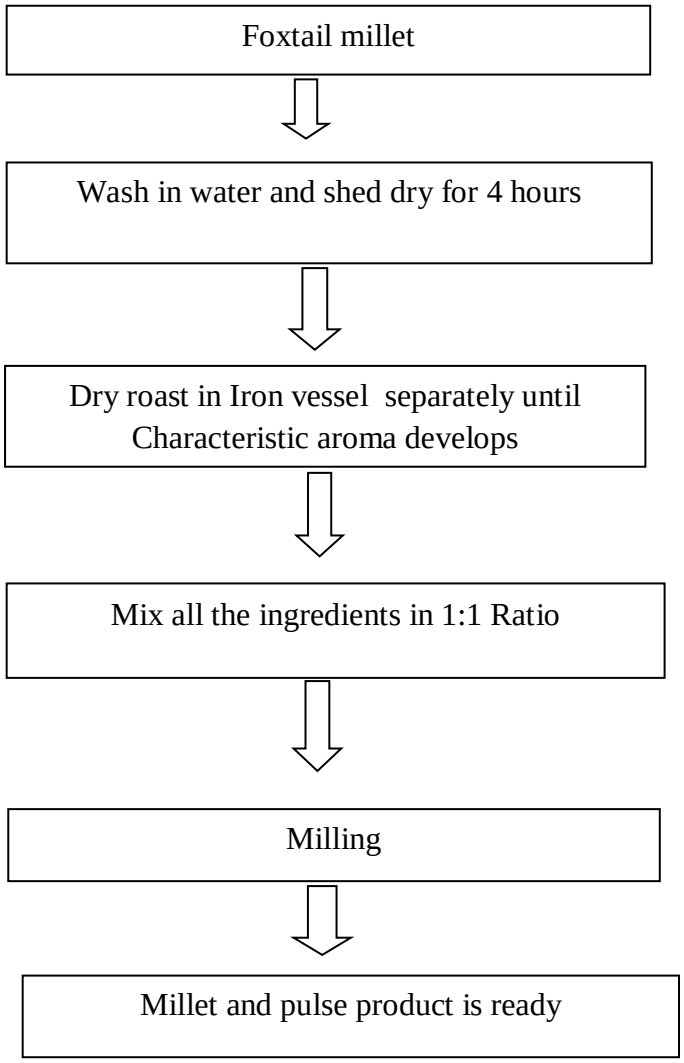
Soyabean used to supplement protein as it is in expensive, low calories, carbohydrates and fats and is important for the people who are allergic to cow protein and lactose. soya protein has no cholesterol and gluten (Ibironke samson ,2022).

Product 2 with Minor millets with four dhals and Horse gram.

Horse gram is known as “poor man’s meat “is significant provider of nutrients, particularly in developing nations. Horse gram has gained recognition for its exceptional protein content and wide array of other essential nutrients.

In cereal-based diets, this quality makes it an excellent dietary element, especially when methionine is the primary amino acid in short supply, and tryptophan and threonine are the other amino acids with minor limitations. (pranav Padmanabhan *et al.*, 2023).

Flow chart of the process



Sensory analysis:

The sensory evaluation is conducted for both the products (P1 & P2) using 9-point hedonic scale. Samples were evaluated for colour, texture, flavour, taste and overall acceptability. porridge is prepared by using product 1&2 then this analysis is conducted by 10 semi trained panel members. Responses are recorded, mean and standard deviation is calculated.

Results and Discussion:

Different products using major and minor millets with combination of dhals, soyabean and horse gram is prepared as per the formulation (P1 and P2). These products are tested for nutritional composition and sensory attributes.

Nutrition analysis:

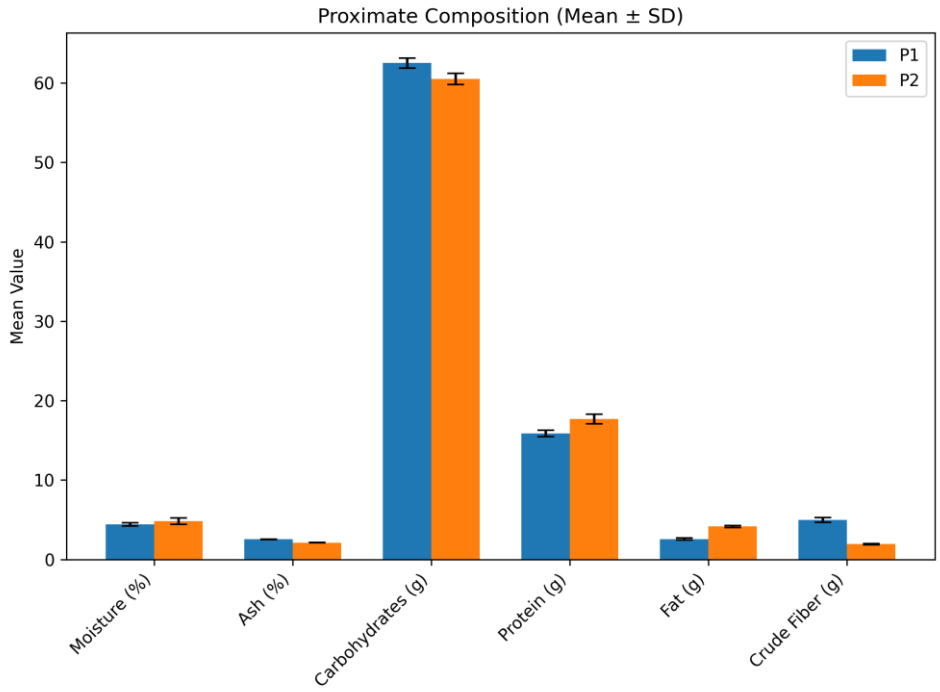
The parameters like moister, ash, carbohydrates, protein, fat, fiber and calcium were evaluated in proximate analysis. all the tests are conducted in triplicates.

Nutritional composition is also compared with the control. control is the product in the market based on millets, pulses, nuts.

Table 3: Nutritional composition of prepared products

Parameters	**C**	**P1**	**P2**
Moister (%)	5.1	4.42 ± 0.20	4.81 ± 0.40
Ash (%)	3.0	2.54 ± 0.011	2.13 ± 0.01
Carbohydrates (gm)	76	62.52 ± 0.64	60.50 ± 0.71
Protein (gm)	10	15.89 ± 0.41	17.70 ± 0.61
Fat (gm)	4	2.58 ± 0.12	4.16 ± 0.13
Dietary fiber (gm)	10	5.00 ± 0.30	1.93 ± 0.07
Calcium (mg)	85	74.50 ± 0.71	102.90 ± 0.90
Iron (mg)	3.5	5.12 ± 0.40	4.91 ± 0.21
Energy (Kcal)	360	339 ± 0.70	352 ± 0.60

Protein content of P2 is higher than that of P1 as the addition of soyabean increases the protein value in the product. compare to control P1 and P2 protein content is higher. The calcium content of P1 is higher compared with P1 and control. addition of finger millet in the P2 contributed most of the calcium. P1 fiber is higher than that of P2. Minor millets are most valuable sources of dietary fiber. Iron content is higher in P1 compare to P2.

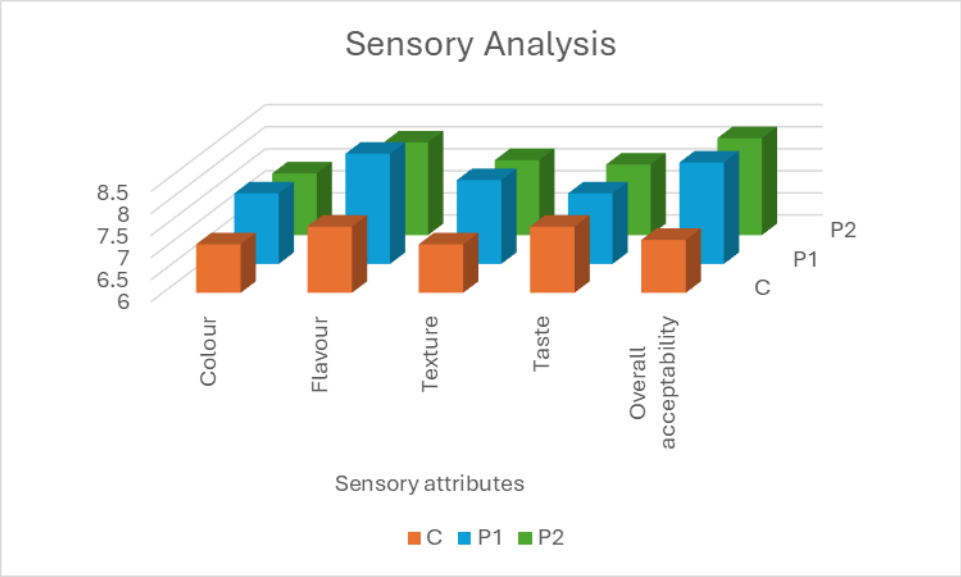


Sensory Evaluation:

Sensory evaluation of the products is conducted by semi trained panel members for various sensory attributes and tabulated as follows.

Table 4: Sensory Evaluation of products

Formulations	**Sensory attributes**				
	Colour	**Flavour**	**Texture**	**Taste**	**Overall acceptability**
C	7.1	7.5	7.1	7.5	7.2
P1	7.6	8.5	7.9	7.6	8.3
P2	7.4	8.1	7.7	7.6	8.2



According to sensory analysis P1 products formulated using minor millets and dhals with Horse gram as the supplementation is more acceptable in terms of colour, texture, flavour, taste and overall acceptability.

Statical Analysis

Overall acceptability of Three products P1, P2 and C (control) are analysed and mean and the Standard Deviation is calculated. The variance is assessed by analysis of Variance (ANOVA) with a probability <0.05.

Table 5: Mean and Standard Deviation (Mean ± SD)

Product	**Overall acceptability**
P1	8.30 ± 0.82^{a}
P2	8.20 ± 0.79^{a}
C	6.90 ± 0.57^{b}

Overall acceptability scores ranged from 6.90 to 8.30 on the 9-point hedonic scale. Among the samples P1 showed the highest overall acceptability (8.30 ± 0.82) followed closely by P2 (8.20 ± 0.79) where as the control sample recorded the lowest score (6.90 ± 0.57). statistical analysis using one way ANOVA revealed a significant difference of ($P<0.05$) among the samples. The highest score of P1and P2 indicate that formulated products were more preferred by the sensory papalists compared to control.

Conclusion:

Millets are the power house of nutrients, antioxidants, phytochemicals, by incorporating millets in the diet have much nutritional benefits such as addressing under nutrition, micronutrient deficiencies (hidden Hunger), over nutrition (obesity). millets are also low in glycaemic index compare to cereals hence can be valuable foods in controlling type II diabetes. Millets are gluten free, high in fiber iron and calcium, which can prevent celiac disease, constipation and cardio vascular diseases. (k Lokesh *et al.*, 2022)

The study concludes that millets and pulse-based formulations are nutritionally superior and sensorily acceptable. The combination enhances protein quality, and contribute to balanced nutrient profile. Such product can be recommended as affordable, nutritious and sustainable options for improving dietary intake. Further studies may focus on shelf-life evaluation and large-scale production.

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