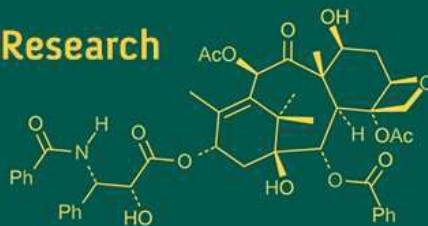
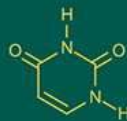


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Physico-chemical properties of grains (cereal, millets and pulses) used in development of multigrain product

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Abstract

The present studies on physico-chemical properties of grains of cereal, millets and pulses used for development of multigrain product was conducted to produce a meal that is fortified with millets and pulses to increase its nutritional content. The formulation included barnyard, sorghum, pearl millet, pigeon pea, green gram, Bengal gram and wheat to make a nutritionally balanced meal rich in proteins, fibre, vitamins, and minerals. The assessment includes a complete examination of physico-chemical properties of grains. The physical properties of grains, including length, width, bulk density, 1000 kernel weight, angle of repose and porosity were measured while the chemical properties of grains including assessment of moisture, protein, fat, ash, carbohydrate and crude fibre disclosing unique dimensions and qualities. Furthermore, the multigrain mixture have low glycemic index makes it a good choice for persons with diabetes and obesity, confirming its significance as a functional food in improving health and wellbeing. Creating multigrain mixture incorporating millet and pulses has the potential to be a more nutritious alternative to regular food products. It contains balanced macronutrient composition. The multigrain mixture has nutritional advantages makes it a great choice for people of all ages, especially those wishing to increase their consumption of whole grains and plant-based proteins. Furthermore, using locally accessible millets and pulses promotes sustainable food security through facilitating the use of underutilized crops.

Keywords: Millet, pulses, cereal, physico-chemical, macronutrient

Introduction

In many parts of the world, people's diets heavily rely on a few staple grains like rice and wheat. By introducing a multigrain mix infused with millets and pulses, encourages diversification of diets and promotes the consumption of alternative millets and pulses. This helps to broaden the range of nutrients for the people to obtain from their food which reducing the risk of nutritional deficiencies. Multigrain mixes are prepared by combining two or more grains together and processed to develop a product with special health benefits. Its basic principle lies in the fact that each grain has its own nutritional profile, thus combining two or more grains may impart additional nutrients. Hence, a multigrain product provides bundle of nutrients, which may not be sufficiently available through single grain consumption.

By incorporating multigrain mixture into our diets, we can take a step towards a healthier future and contribute to the fight against malnutrition worldwide. For developing multigrain mixture whole grains have been used. Consuming whole grains is associated with a lower risk of cardiovascular diseases, certain cancers and improved digestive health. Recent research has focused on enhancing the nutritional value and convenience of product by incorporating cereal, millets and pulses.

Materials and Methods

The present study was carried out to develop multigrain Dalia incorporated with millets and pulses. The acceptability, nutritional composition, and storage study of prepared multigrain Dalia incorporated with millets and pulses were evaluated.

Materials

Raw materials such as barnyard, sorghum, pearl millet, wheat, pigeon pea, green gram and Bengal gram will be sourced from the local market in Parbhani, while chemicals and

reagents will be acquired from the laboratory at the Department of Food Science and Nutrition, College of Community Science and Department of Food Plant Operations, College of Food Technology, VNMKV, Parbhani (MS).

Chemicals and glassware

Chemicals of analytical grade and sufficient glassware required were available in the laboratory, Department of Food Science and Nutrition, College of Community Science and Department of Food Plant Operations, College of Food Technology, VNMKV, Parbhani (MS).

Equipments

The equipment and machinery needed for this course of study, such as a weighing balance, hot air oven, vernier calliper, spectrophotometer, Micro-Kjeldahl, Soxhlet apparatus, atomic absorption spectrophotometer, and muffle furnace, were utilized for the current investigation and were provided by the Department of Food Science and Nutrition at the College of Community Science and Department of Food Plant Operations, College of Food Technology, VNMKV, Parbhani (MS).

Method

Physical analysis of sample

Length and width

A vernier calliper was used to measure the axial dimensions of randomly selected grains for length, width in millimeter (mm).

1000 Kernel Weight

Average weight of 1000 grains of barnyard, sorghum, pearl millet, wheat, pigeon pea, green gram, Bengal gram was determined using electronic weighing balance.

Bulk density

Bulk density was determined by filling the sample gently in a container of known volume and weighed. The ratio between the weight and volume was calculated as bulk density in (kg/m³).

$$\text{Bulk density} = \frac{\text{Mass of sample}}{\text{Volume of sample}}$$

Angle of Repose

Angle of repose was determined by making a circular pile of the grains freely falling. The height of the pile was taken (h) and its radius R was measured.

$$\text{Angle of Repose } (\phi) = \tan^{-1} (h/r)$$

Porosity

This involves physically measuring the bulk volume of the sample and then determining the grain volume through various means, such as crushing the sample and using a pycnometer. The porosity is calculated using the formula:

$$\text{Porosity} = \frac{V_p}{V_b} \times 100$$

Where, V_p is the pore volume and V_b is the bulk volume

Proximate of samples

Grains were analyzed for proximate composition, including moisture, fat, protein, total carbohydrate, crude fiber, ash,

and mineral composition as per the methods given by (AOAC, 2005) [16].

1. Determination of Moisture

Moisture content was determined by precisely measuring the weight of a 5 g sample, which was then ground and exposed to oven drying at 105 °C for 4 hours. After cooling in desiccators until a consistent weight was achieved, the loss in weight was calculated as the moisture content following the AOAC (2005) [16] method.

$$\text{Moisture (\%)} = \frac{\text{Initial weight(before drying)} - \text{Final weight(after drying)}}{\text{Total weight of sample}} \times 100$$

2. Determination of Fat

A 5 g sample, dried on the ground, was precisely weighed in a thimble and then purified by removing the fats using petroleum ether in a Soxhlet apparatus for 6-8 hours at 60 °C. The extracted ether was then evaporated, and the lipid content was determined according to the AOAC (2005) [16] method.

$$\text{Fat (\%)} = \frac{\text{Final weight of flask} - \text{Empty weight of flask}}{\text{Weight of sample}} \times 100$$

3. Determination of Protein

The protein content was assessed using the Micro-Kjeldahl method following the procedure outlined in AOAC (2005) [16].

Digestion

An exact 200 mg (0.2 g) of the defatted ground sample was combined with 1 g of a catalyst mixture comprising K₂SO₄:CuSO₄:HgO (red) in a ratio of 91:8.2:0.8 g. This mixture was then transferred into a digestion flask, and the digestion process took place with the addition of 5 ml concentrated H₂SO₄ for 25-30 minutes at 420 °C using an infrared Kjeldahl digestion system until the content became colorless.

Neutralization and Distillation

The digested sample was diluted to a final volume of 50 ml in a volumetric flask using double-distilled water. Subsequently, a 5 ml aliquot of the diluted sample was neutralized with a 40 percent NaOH solution containing 5 gm of sodium thiosulfate. Distillation was then performed, and the released ammonia was absorbed in a 2 percent boric acid solution with methyl red serving as the indicator.

Titration

The ammonia collected was titrated against a 0.01N H₂SO₄ solution, and the titration reading was recorded. The percent nitrogen content was calculated using the following formula, and the percent protein content was determined by multiplying it by a factor of 6.25. A blank sample was run in parallel to account for any background or interference.

$$N(\%) = \frac{\text{CBR} \times \text{Normality}}{\text{Weight of sample}} \times 100$$

Where,

CBR = Correct burette reading

= Sample burette reading (SBR) – Blank burette reading (BBR)

Normality of acid (H₂SO₄) = 0.01N

Moles of Nitrogen = 14/1000

Percent Protein = percent Nitrogen × 6.25

1. Determination of total Carbohydrate

The content of carbohydrate in the sample was obtained by subtracting the sum of value of moisture, protein, fat, ash and crude fiber content per 100 gm of the sample from 100.

$$\text{Carbohydrate} = 100 - (\text{Moisture} + \text{Protein} + \text{Fat} + \text{Ash} + \text{Crude fiber})$$

2. Total Ash

The determination of total ash content was conducted in accordance with the A.O.A.C. (2005) [16] guidelines. A 5 g sample was placed into a crucible and ignited over a low flame until all the material had completely turned smokeless. Subsequently, it was transferred to a muffle furnace and maintained at 550 °C for 5 hours before being allowed to cool inside a desiccator. After each cycle of heating and cooling, the sample's weight was measured. This process was repeated until two consecutive weight measurements remained constant, at which point the percentage of ash content was calculated by noting the difference between the initial and final weights.

$$\text{Ash (\%)} = \frac{\text{Weight before heating} - \text{Weight after heating}}{\text{Weight of sample}} \times 100$$

Table 1: Physical parameters of millets and cereal

Parameters	Length (mm)	Width (mm)	1000 kernel weight(g)	Bulk density (kg/m ³)	Angle of Repose (Degree)	Porosity (%)
Barnyard	1.79	1.72	3.48	748.0	20.3	3.40
Sorghum	4.50	3.89	33.23	741.46	34.32	41.26
Pearl Millet	3.50	2.67	10.12	815	27.5	37.6
Wheat	6.50	3.41	51.62	732	27.1	44.2

*Each value is a mean of three determinations

Table 2: Physical parameters of pulses

Parameters	Length (mm)	Width (mm)	1000 kernel weight(g)	Bulk density (kg/m ³)	Angle of Repose (Degree)	Porosity (%)
Pigeon Pea	6.1	5.7	169.4	678.3	27.23	43.30
Green gram	4.84	3.49	34.57	778.9	27.2	44.1
Bengal gram	8.0	6.0	275.3	674.62	33.15	52.04

*Each value is a mean of three determinations

Proximate analysis of grains

Proximate analysis gives inexpensive yet very important information, particularly from the nutritional and biochemical points of views. The results normally expressed in percentage and because of the fairly general nature of test employed for the determination, the term crude is usually used as a modifier; for instant, crude protein, crude fat and

Results

The present investigation entitled was carried out in Department of Food Science and Nutrition, College of Community Science and collaboration with Department of Food Plant Operations, College of Food Technology, VNМКV, Parbhani (Maharashtra) during the year 2023-2024.

In the present investigation, multigrain Dalia have been developed using varying ratios of barnyard millet and germinated grains of sorghum, pearl millet, wheat, pigeon pea, green gram and Bengal gram, which offers numerous conveniences for breakfast, including quick cooking time, versatility in recipes, high fiber content for satiety, easy digestion and the ability to customize with various toppings. The raw materials were subjected for the analysis of physico-chemical parameters. The results obtained during the experiment were recorded and analyzed statistically, presented under appropriate headings, sub-headings.

Physical parameter of grains

Data pertaining to physical properties such as length, width, weight of 1000 seeds, bulk density, angle of repose and porosity were analysed and depicted in Table 1 and 2.

crude fiber etc. Therefore, proximate constituent represents only a category of compounds present in biological material (Acharya and Karki, 2008) [1].

The study investigates nutritional components of raw material such as moisture, protein, fat, carbohydrate, ash and crude fiber expresses in percentage for cereal and millets in table 3 and for pulses depicted in Table 4.

Table 3: Proximate composition of cereal and millets

Parameters	Barnyard	Sorghum	Pearl millet	Wheat
Moisture (%)	9.94 ± 0.05	10.97±0.67	9.72±0.60	8.44±1.11
Protein (%)	8.22± 0.02	11.87±0.42	9.96±0.26	18.69±0.60
Fat (%)	2.32 ± 0.02	3.03±0.33	5.43±0.64	3.29±0.05
Carbohydrate (%)	76.09± 0.11	67.18±1.03	71.55±0.85	62.70±1.74
Ash (%)	1.05 ± 0.01	2.87±0.17	1.37±0.17	3.42±0.19
Fiber (%)	2.38 ±0.98	4.07 ± 0.93	1.97±0.89	3.46±1.091

*Each value is a mean of three determinations

Table 4: Proximate composition of pulses

Parameters	Pigeon Pea	Green gram	Bengal gram
Moisture (%)	8.43±0.02	9.01 ±0.45	9.64±0.43
Protein (%)	19.06±0.02	23.98±0.33	16.9 ± 0.32
Fat (%)	1.74±0.03	1.81±0.33	4.75 ± 0.22
Carbohydrate (%)	62.86±61.50	57±0.22	61.45 ± 0.50
Ash (%)	3.27±0.03	3.79±0.04	2.85 ± 0.1
Fiber (%)	4.64±0.02	4.41±0.25	4.41 ± 0.90

*Each value is a mean of three determinations

Discussion

Physical Properties

Data from the table 1 and 2 reveal that the dimensional parameters such as length and width were measured to be 1.79 and 1.72 (mm), 4.50 and 3.89(mm), 3.50 and 2.67 (mm), 6.50 and 3.41(mm), 6.1 and 5.7(mm), 4.84 and 3.49(mm), 8.0 and 6.0(mm) for barnyard, sorghum, pearl millet, wheat, pigeon pea, green gram and Bengal gram respectively.

The weight of 1000 seeds, bulk density, angle of repose and porosity were measured and noted for barnyard to be 3.48 g, 748.0 kg/m³, 20.3°, 3.40 % for sorghum 33.23 g, 741.46 kg/m³, 34.32°, 41.26 % for pearl millet 10.12 g, 815 kg/m³, 27.5°, 37.6 % for wheat 51.62 g, 732 kg/m³, 27.1°, 44.2% for pigeon pea 169.4 g, 678.3 kg/m³, 27.23°, 43.30 % for green gram 34.57 g, 778.9 kg/m³, 27.2°, 44.1 % and for Bengal gram 275.3 g, 674.62 kg/m³, 33.15°, 52.04 % respectively.

Similar findings for the physical properties of barnyard were similar to the result reported in Annu *et al.*, (2024) [3] as length and width are 2.42 mm and 1.94 mm, 1000 grain mass was 3.65 g, bulk density was 760.0 kg/m³, angle of repose 21.2°, porosity 3.81%.

For sorghum similar findings for the physical parameters such as length and width as 4.56 to 4.10 mm, and 3.99 to 3.59 mm respectively, the thousand grains weight ranged from 27.56 to 36.10 g, the bulk density ranged from 700.04 to 769.49 kg/m³, angle of repose was ranged from 34.32° to 38.80° and porosity was ranged from 0.4038 to 0.4267 by R.A. Gosavi *et al.*, (2023) [11].

Similar findings for the physical parameters of pearl millet, ranged from 3.16 to 3.87 mm, and 2.30 to 2.93 mm respectively, the thousand grains weight ranged from 7.3 to 9.47 g, the bulk density ranged from 811.4 to 817.64 kg/m³, angle of repose was ranged from 32.67 to 29.33, and porosity was ranged from 15.17 to 17.28 by Ojedian, *et al.*, (2010) [10].

Physical parameters of wheat found to be similar ranged from 6.64±0.41 to 7.36±0.43 mm and 2.51±0.17 to 3.95±0.27 mm respectively, the thousand grains weight ranged from 23.2 g to 39.7 g, the bulk density ranged from 740 to 538.8 kg/m³, the angle of repose was ranged from 34.7 to 45°, as moisture content increased from 0% to 22% d.b., the porosity of wheat grains increased from 45 % to 49 % by Tabatabaeefar (2003) [15].

Similar findings for the physical properties of pigeon pea i.e., at moisture content increased from 10 to 25 % w.b. the length, width ranged from 0.63 to 0.69 mm, and 0.62 to 0.67 mm respectively, the thousand grains weight increased linearly from 167.6 to 181.6 g, the bulk density ranged from 685.16 to 640.55 kg/m³, angle of repose was ranged from 26.70 to 28.70°, the porosity of pigeon pea grains increased from 43.40 % to 13.55 % by Obi *et al.*, (2014) [9].

Similar findings for the physical properties of green gram i.e., length of the green gram is 4.9mm, width 3.7mm, thousand grains weight 35.6 g, the bulk density 756.81 kg/m³, angle of repose was 27.6° and porosity 40.8 % were reported by Dahiya, *et al.*, (2015) [4].

For Bengal gram similar finding were reported by Dhake *et al.*, (2017) i.e., the average length and width of Bengal gram at moisture content of 6.15 % d. b. was 9.536 mm, 6.785 mm respectively, 1000 kernel weight increases linearly from 242.36 to 342 g as at moisture content ranged from 6.15 % d. b. to 25.27 % d.b., bulk density of seed at different

moisture levels varied from 714.86 to 593.90 kg/m³, the angle of repose increased from 22.15 to 35.0 in the moisture range of 6.15-25.27 % d.b., porosity increased from 49.477 to 56.004% as the moisture content increases from 6.15 to 25.27 % d. b.

Chemical Properties

The tabulated data in Table 3 deals with the chemical composition of barnyard millet i.e., moisture, protein, fat, carbohydrate, ash and fiber in barnyard to be 9.94 percent, 8.22 percent, 2.32 percent, 76.09 percent, 1.05 percent, and 2.38 percent respectively which is major ingredient used for development of multigrain mixture which is found similar to the data that reported in Lohani *et al.*, (2010) [8]. It was evident from table 3 that moisture, protein, fat, carbohydrate, ash and fiber in sorghum is found to be 10.97 percent, 11.87 percent, 3.03 percent, 67.18 percent, 2.87 percent, and 4.08 percent respectively which is similar to study were reported by Kayisoglu *et al.*, (2024) [6] as moisture 11.31 percent, ash 2.05 percent, protein 12.58 percent, carbohydrates 53.71 percent, fibre 4.8 percent and fat 3.49 percent. The tabulated data in table 3 deals with the proximate composition of pearl millet i.e., moisture, protein, fat, carbohydrate, ash and fiber is to be 9.72 percent, 9.96 percent, 5.43 percent, 71.55 percent, 1.37 percent, and 1.97 percent respectively which is found similar to the values reported in Suma & Urooj (2014) [14]. It was evident from table 3 that chemical composition of wheat i.e., moisture, protein, fat, carbohydrate, ash and fiber is to be 8.44 percent, 18.69 percent, 3.29 percent, 62.70 percent, 3.42 percent, and 3.46 percent respectively which is found to be similar to the values reported by Adeyeye, (2024) [2].

The tabulated data in table 4 deals with the chemical composition of pigeon pea i.e., moisture, protein, fat, carbohydrate, ash and fiber is to be 8.43 percent, 19.06 percent, 1.74 percent, 62.86 percent, 3.27 percent, and 4.64 percent respectively which is similar to the findings reported in Rizvi, *et al.*, (2022). The tabulated data in table 4 deals with the proximate composition of green gram i.e., moisture content, protein, fat, carbohydrate, ash and fiber in raw form is to be 9.01 percent, 23.98 percent, 1.81 percent, 57.0 percent, 3.79 percent, and 4.41 percent respectively which is found is similar to values reported by Sharma *et al.*, (2013) [13]. The tabulated data in table 4 deals with the chemical composition of Bengal gram i.e., moisture, protein, fat, carbohydrate, ash and fiber is to be 9.64 percent, 16.9 percent, 4.75 percent, 61.45 percent, 2.85 percent, and 4.41 percent respectively which is similar to values reported by Sharma *et al.*, (2013) [13].

Summary and Conclusion

Thus, based on the scientific data collected and analyzed, it can be concluded that physico-chemical parameters studies of barnyard, sorghum, pearl millet, wheat, pigeon pea, green gram and Bengal gram are vital for the development of multigrain mixture. Physical properties of grains such as length, width, weight of 1000 seeds, bulk density angle of repose and porosity was determined to ensure uniformity and consistency of final product, designing equipment, processes to handle the materials effectively, to optimize the manufacturing process, help to efficient mixing, preventing issue like uneven mixing of ingredients and chemical parameters such as moisture, protein, fat, carbohydrate, ash

and crude fiber ensures development of higher nutritional quality products.

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