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Original Research Article

Pharmacognostical and Nutritional Assessment of Sprouted *Pennisetum glaucum* and *Sorghum bicolor* as Body-Sustaining (Dhatu-Poshaka) Functional Foods in Ayurveda

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Abstract

Background: The concept of Dhātu-Poṣaṇa in Ayurveda emphasizes the role of wholesome diet in nourishing body tissues and maintaining physiological equilibrium. Sprouted millets, traditionally used in Indian diets, are gaining scientific attention as functional foods because sprouting increases enzymatic activity and improves their nutritional and bioactive properties. Objective: The present study aimed to evaluate the pharmacognostical and nutritional properties of sprouted *Pennisetum glaucum* L. and *Sorghum bicolor* L. and to explore their potential as Dhātu-Poṣaka functional foods in Ayurveda. **Methods:** The sprouted grains were subjected to pharmacognostical evaluation including macroscopic, microscopic, physicochemical analysis for quality valuation and nutritional value assessment. **Results:** Germination was found to enhance organoleptic characteristics, improve structural features, and increase the availability of nutrients. Preliminary phytochemical analysis revealed the presence of phenolics, flavonoids, carbohydrates, proteins, and essential macro and micronutrients assessment confirmed that sprouting of these grains possess significant nutritional properties. **Conclusion:** In conclusion, pharmacognostical standardization demonstrates that sprouted *P. glaucum* and *S. bicolor* possess significant nutritional and therapeutic attributes, supporting their use as Dhatu-Poshaka functional foods in Ayurveda. Further studies may help establish their clinical relevance in health promotion.

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Introduction

Medicinal plants and dietary grains have long been essential sources for the identification of bioactive substances with potential medical applications. Scientific interest in investigating functional foods—which offer health advantages beyond basic sustenance—has grown in recent years [1]. In Ayurveda, the concept of Dhātu-Poṣaka plays a central role in understanding nutrition, growth, and maintenance of health. The term is derived from two Sanskrit words: Dhātu, meaning the fundamental structural and functional body tissues, and Poṣaka, meaning nourishment or sustenance. Thus, Dhātu-Poṣaka refers to substances, particularly foods and herbal preparations that promote nourishment, development, and proper functioning of body tissues [2]. Proper nourishment of Dhātus (Rasa: nutrient plasma), (Rakta: blood), (Māṃsa: muscle), (Meda: adipose tissue), (Asthi: bone), (Majjā: marrow and nervous tissue), and (Śukra: reproductive tissue) depends on efficient digestion and metabolism, which transform ingested food into progressively refined tissue elements. Dhātu-Poṣaka supported this sequential nourishment, ensuring tissue integrity, vitality, strength, and overall well-being [3]. Dhātu-Poṣaka foods are rich in essential nutrients, enhance digestion and assimilation, and contribute to tissue building and repair. Such substances are often associated with strength promoting, rejuvenating and important in preventive healthcare, disease management [4]. Among such functional foods, cereal grains such as pearl millet *Pennisetum glaucum* (L.) R.Br. and sorghum *Sorghum bicolor* (L.) belonging to the family Poaceae have attracted considerable attention due to their rich phytochemical profile and adaptability to diverse agro-climatic conditions. *P. glaucum* and *S. bicolor* are staple crops widely cultivated in arid and semi-arid regions, particularly in developing countries. These grains are valued not only for their nutritional content, comprising carbohydrates, proteins, dietary fiber, vitamins, and minerals, but also for their significant levels of bioactive constituents such as phenolic compounds, flavonoids, tannins, unsaturated fatty acids, and antioxidants. It is well recognized that these phytoconstituents are essential for lowering the oxidative stress and minimizing risk of chronic illnesses, including cardiovascular disorders, antidiabetic, cholesterol-lowering properties and neurodegenerative conditions [5-6]. Traditionally, they are consumed in the form of flatbreads (rotis), porridges, fermented foods, and beverages. In rural communities, it remains a staple food due to its affordability and adaptability [7]. Importantly, both plant grains are valued for their low glycemic index, gluten-free, making it suitable for individuals with celiac disease or gluten intolerance. In modern times, its nutritional properties have enhanced its value in the functional food and nutraceutical industry, where it is used in health foods, gluten-free products, and dietary supplements [8].

Sprouting enhances its nutritional, phytochemical, and nutritional properties. Sprouted grains are considered more bioactive due to increased enzymatic activity and breakdown of antinutritional factors. Sprouting enhanced the phyto-constituents like phenolic compounds such as ferulic acid, caffeic acid, gallic acid, and catechins and flavonoids like quercetin, luteolin, apigenin, phytosterols like β-sitosterol, stigmasterol present in *P. glaucum* and *S. bicolor* grains. During sprouting reduced the content of tannins, saponins and C-glycosylflavones and

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improving bioavailability and level of vitamins like vitamin E, vitamin C, B-complex (especially folate). After sprouting increases the content of minerals like calcium, iron, magnesium, zinc and amino acids & peptides like lysine and methionine [9]. Pharmacognostical evaluation plays a pivotal role in the identification, authentication, and quality control of plant materials. It involves the detailed study of macroscopic and microscopic characteristics, physicochemical parameters, and organoleptic properties, which are essential for ensuring the purity, safety, and efficacy of herbal products. In the case of sprouted cereal grains, pharmacognostical standardization is particularly important to establish diagnostic features that distinguish them from raw grains and to prevent adulteration [10]. The enhanced phytochemical composition of sprouted *P. glaucum* and *S. bicolor* may suggests their potential in exhibiting various pharmacological effects largely attributed to the synergistic action of their secondary metabolites, which modulate multiple biochemical pathways involved in disease pathogenesis [11]. The present study aims to carry out Pharmacognostical and nutritional value assessment of sprouted *P. glaucum* and *S. bicolor* to establish their potential as Dhātu-Poṣaka functional foods in Ayurveda. Such an approach may contribute to the scientific validation of traditional dietary practices and promote the use of sprouted millets as nutritionally enriched therapeutic foods for maintaining health and preventing lifestyle-related disorders.

Materials and Methods

Procurement and certification of plant material

S. bicolor and *P. glaucum* grains was purchased in October 2022 from dharmshala market of district Gorakhpur (India) and validated by the All-India Institute of Ayurveda (AIIA), New Delhi to find out the reference number (RRDR/AIIA/phg. /132) and (RRDR/AIIA/phg. /133).

Instruments and chemicals

The UV spectra were measured using a Lambda Bio 20 Spectrophotometer from Shimadzu-U Singapore. Analytical TLC was performed with Silica gel G from Qualigens. Spots were detected by exposing them to iodine vapors and a UV Lamp at 254 nm. All chemical and solvents were sourced from Merck chemical supplies in Damstadt, Germany, while rutin and gallic acid were obtained from Qualigens chemical suppliers.

Sprouting of the grains and extract preparation

The grains were cleaned to remove dust, stones, and other impurities. For the optimal sprouting, 100 g of *P. glaucum* and *S. bicolor* grains were divided in to two parts and each part were thoroughly washed with distilled water to remove dust, debris, and broken particles. To reduce microbial contamination, the grains were surface sterilized by soaking in 0.1% sodium hypochlorite solution for 5 minutes. The grains were then rinsed 3-4 times with sterile distilled water to remove any residual disinfectant. The sterilized grains were soaked in sterile distilled water for 10-12 hours at room temperature (32-40°C) to facilitate hydration and initiate germination. After soaking, excess water was drained and the grains were spread evenly on sterile germination trays lined with sterile moist muslin cloth. The trays were covered with sterile cloth and incubated under controlled conditions at 32-40°C. To maintain adequate moisture and prevent microbial growth, the grains were rinsed with sterile distilled water every second day and excess water was removed to avoid water stagnation. The

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grains were allowed to germinate for 12 days, and the germination process was monitored regularly. Any grains showing visible fungal or bacterial contamination were immediately discarded [12]. The sprouted grains were used for the morphological and microscopical studies. The sprouted grains were dried on hot blower and then milled into a coarse powder used for further study. Following a 72-hour cold maceration process, 50 g of the powdered sprouted grains and 25g fresh unsprouted grains were extracted with 150 and 50 mL of 90% v/v ethanol [13]. The extract was passed through muslin cloth for filtration, after which the filtrate was concerted under reduced pressure and subsequently vacuum-dried. The dried extracts were stored at 4 °C until further analysis.

Pharmacognostical evaluation

Gently separate the sprouted root, shoot, and the remaining seed tissue. The macroscopic characteristics of raw and sprouted grains such as size, shape, colour, surface texture, odour, and taste were recorded according to standard Pharmacognostical procedures. Place a small piece of the sprouted tissue on a glass slide and cut fine section with help sharp razorblade. Stains with safranin to visualize cell walls and internal structures more clearly. Use a light microscope to observe the changes in cell structure and tissue organization compared to a dry seed. Standard physicochemical parameters like Loss on drying, Total ash, Acid insoluble ash, Water soluble ash, extractive value in Pet. Ether, Chloroform, and Methanol determined following pharmacopeial guidelines. Qualitative phytochemical analysis of the extractives was carried out to detect the presence of major secondary metabolites using standard phytochemical tests. The TLC fingerprint of both plant methanolic extract was analysed using, mobile phase Methanol : Chloroform ratio of (60 : 40). Iodine vapours was used as detecting agent. The Rf values were and colours are recorded [14-15].

Nutritional analysis

The nutritional composition of sprouted grains of *P. glaucum* and *S. bicolor* was evaluated to determine their potential as Dhātu-Poṣaka functional foods. All analyses were performed in triplicate and results were expressed on a dry weight basis. The instant composition of the powdered sprouted grains was determined using standard analytical procedures.

Moisture content

Moisture content was determined by hot air oven method. Approximately 2 g of sample was accurately weighed in a pre-weighed moisture dish and dried at 105 °C until constant weight was obtained. The percentage moisture content was calculated using the formula:

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Total Ash content

Total ash was determined by incinerating 2 g of sample in a silica crucible at 550 °C in a muffle furnace until carbon-free ash was obtained. The ash content represents total mineral content [16].

Total carbohydrate, crude protein, crude fat, and crude fibre content

Total carbohydrate content was calculated by difference

Carbohydrates (%) = 100 – (Moisture + Protein + Fat + Ash + Fibre)

The Kjeldahl method was employed to determine the crude protein content. The procedure involved digesting the sample with concentrated sulfuric acid alongside a catalyst mixture. Ammonia released during this process was distilled into boric acid and then titrated using

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standard hydrochloric acid. The nitrogen content measured was then multiplied by a conversion factor of 6.25 to compute the crude protein [17].

The crude fat content was assessed using the Soxhlet extraction technique. A sample weighing approximately 2–3 g was subjected to extraction with petroleum ether at a temperature range of 60–80 °C for a duration of 6 hours. Following the extraction process, the solvent was evaporated, and the remaining residue was weighed to ascertain the fat content [18-19].

Crude fibre was estimated by sequential acid and alkali digestion. The defatted sample was boiled with dilute sulfuric acid followed by dilute sodium hydroxide. The residue obtained was dried, weighed, incinerated, and crude fibre percentage was calculated [20-21].

Macro and microelements

The quantitative mineral estimation of sprouted *Sorghum bicolor* and *Panicum glaucum* was carried out to determine the levels of essential minerals such as calcium, iron, magnesium, potassium, phosphorus, sodium, and zinc. A known quantity of powdered sprouted grain samples was treated with concentrated nitric acid and perchloric acid and heated until a clear solution was obtained. The digested samples were filtered and diluted with distilled water to a known volume. The mineral contents were analyzed using Atomic Absorption Spectrophotometry (AAS) for minerals such as iron, zinc, calcium, and magnesium, while sodium and potassium were estimated using a flame photometer. Phosphorus content was determined colorimetrically using the molybdenum blue method. Standard calibration curves were prepared using analytical grade standard solutions for each mineral. The obtained mineral concentrations were expressed as mg/100 g of dry weight sample [22-23].

Statistical analysis

Statistical analysis was performed using GraphPad Prism / SPSS. All experiments were carried out in triplicate (n = 3), and the results were expressed as mean ± standard deviation (SD). Statistical comparison between raw and sprouted grains was performed using one-way ANOVA followed by Tukey's post hoc test.

Results and Discussion

Morphology of unsprouted and sprouted *P. glaucum* grains

The fresh grains of *P. glaucum* are caryopsis type typically small, hard, rounded globose to conical shape, usually blackish white, yellowish grey to brown colour. The sprouted grains become soft and tender, with a smooth texture, primarily features the emergence of a radicle and a plumule, which are the root and shoot, respectively. As germination progresses, a feathery tuft of root hairs develops from the radicle, and the plumule elongates to form the initial leaves and stem. The overall structure transforms from a compact, ovoid to cylindrical grain into a seedling with a distinct root system, a sturdy, often hairy stem, and a developing leaf blade. During sprouting the grains get swells due to water absorption. The protective seed coat begins to split in to radicle emerges from the grain, anchoring the seedling. It grows downward, eventually developing a profuse system of secondary roots with abundant root hairs for water and nutrient absorption. The embryonic shoot (plumule) emerges and grows upwards contains the nascent shoot, which forms the first leaves (leaf primordia) and the initial stem internodes. The emerging shoots are typically smooth, with prominent nodes, and can be quite sturdy. The length of the sprouts can vary depending on the sprouting time. For

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example, some studies note sprouts of 1–3 mm after three days. Longer sprouts can be grown by continuing to rinse the grains. During sprouting, the grain itself becomes lighter in colour, a result of enzymatic activity and the removal of the fibrous outer layers. Sprouted grains are typically odourless and tasteless, while the unsprouted grains have a more distinct, subtle flavour.



Fig.1: *Pennisetum glaucum*. (A) unsprouted grains (B & C) sprouted grains

Morphology of unsprouted and sprouted *S. bicolor* grains

The grains of *S. bicolor* are white colour with smooth and glossy surface, round to oval or slightly oblong in shape. Average size ranges from 3-5 mm in diameter. Each grain consists of Pericarp (outer covering) thin, smooth, and tightly adhering to the seed coat. Hilum is small inconspicuous and germ located at one side of the grain. Endosperm constitutes the major portion of the grain. Embryo is relatively small compared to endosperm laterally placed contains scutellum and plumule.



Fig.2: *Sorghum bicolor*. (A) unsprouted grains (B & C) sprouted grains

Microscopical features

Microscopy of sprouted pearl millet shows the development of new anatomical features in addition to the components of the original grain. Compared to the powder microscopy of unsprouted seeds, sprouted seeds show new features such as vessels, and cork cells.

Microscopically, sprouted *P. glaucum* showed a more developed embryo, particularly the elongating radicle, and increased cellular activity compared to a dry seed. The signs of germination such as hydrated tissues, increased cell wall elasticity, and the potential elongation of the xylem vessels within the developing

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root and shoot tissues. The most visible sign of sprouting is the elongation of the embryo, particularly the radicle (the first root to emerge). Development of xylem and phloem as the plant grows, new vascular tissues will begin to differentiate to transport water and nutrients throughout the sprout (Fig.3).

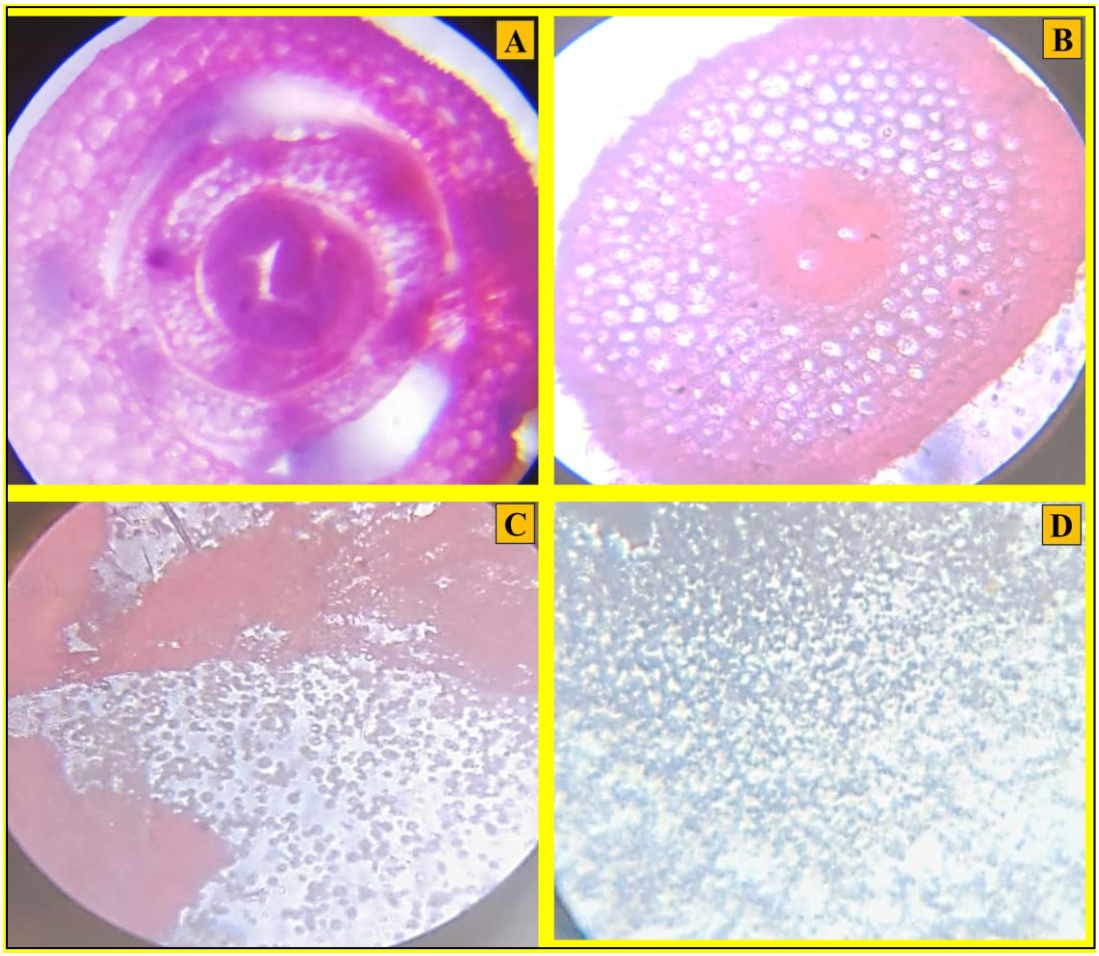


Fig.3: T.S. of Sprouted grains of *Pennisetum glaucum* (A) Germ; (B) Plumule, (C) Endosperm with starch grains, (D) Starch grains

Microscopical evaluation of sprouted grains of *S. bicolor* reveals structural modifications associated with germination, particularly in the pericarp, endosperm, and embryo regions.

The pericarp appears as a thin outer layer composed of elongated compact cells rectangular to polygonal in surface view. In sprouted grains, observed partial loosening and separation of pericarp layers. The testa is composed of compressed thin-walled cells contains phenolic materials appearing as brown contents. During sprouting, testa get partial rupture due to radicle emergence. Aleurone grains are situated in single-layered cubical to rectangular cells. In sprouted grains, aleurone cells show enzymatic activation and partial depletion of storage materials.

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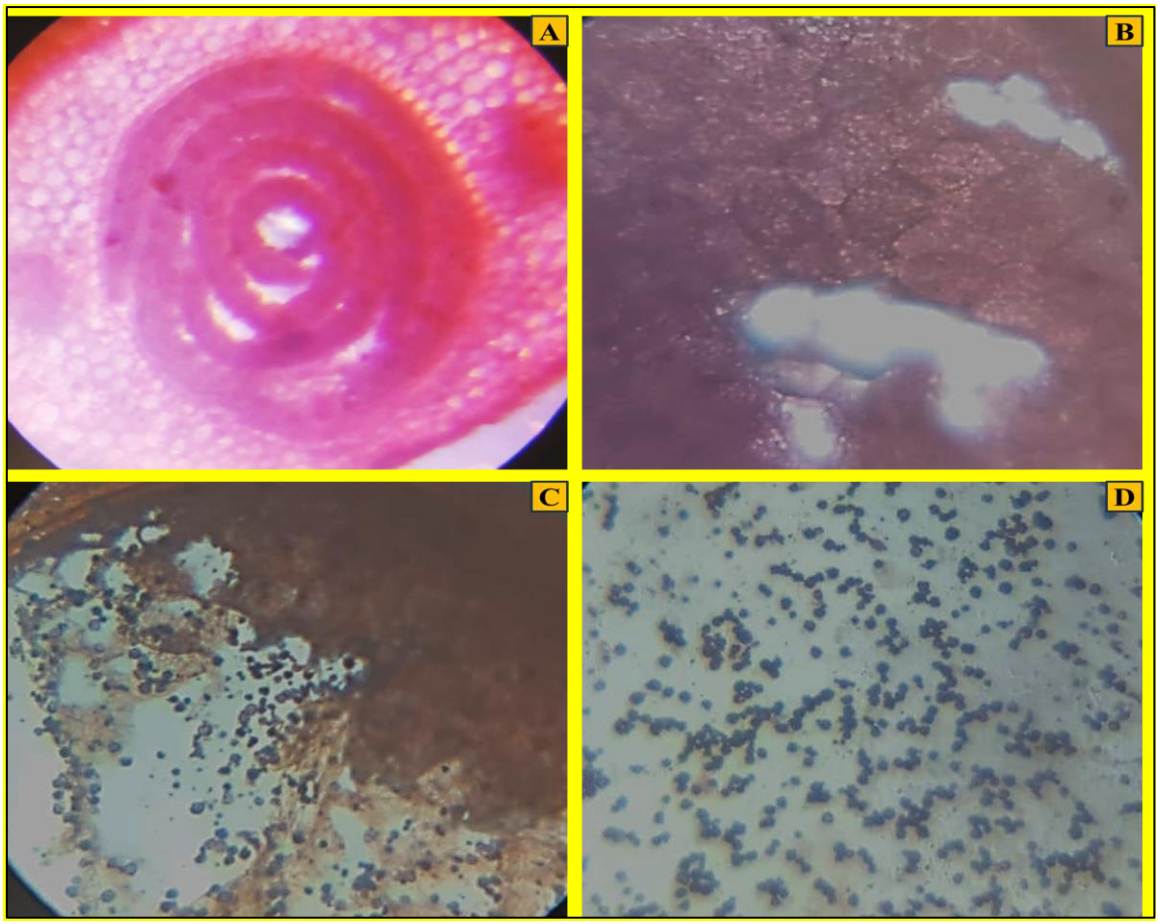


Fig.4: T.S. of Sprouted grains of *Sorghum bicolor* (A) Germ; (B) Endosperm, (C) Endosperm with starch grains, (D) Starch grains.

Endosperm is differentiated into corneous endosperm and thick-walled compact cells contain densely packed polygonal starch granules. In sprouted grains starch degradation begins cells appear loosely arranged and cell wall softening. Embryo becomes prominent and enlarged after sprouting consists of scutellum, plumule, and radicle. Developing vascular strands visible near embryo. Xylem elements appear as elongated thick-walled cells and phloem tissue composed of thin-walled conducting cells (Fig.4). Sprouting activates enzymes like phytase, which reduce anti-nutritional factors and break down starches and proteins to make them available for the growing embryo. The microscopic appearance of starch grains changes as they are consumed during growth.

Extractive values

Successive extractive values with different solvents of powdered raw and sprouted grains were performed. The percentage of extractive values in triplicate and their mean values ± SD was calculated with reference to the air-dried sample **Table 1.**

Table 1: Extractive values for powdered raw and sprouted grains with different solvents.

Type of solvent	**Raw *P. glaucum***	**Sprouted *P. glaucum***	**Raw *S. bicolor***	**Sprouted *S. bicolor***
Pet. ether	1.24 ± 0.26	1.48 ± 0.22	1.32 ± 0.25	1.64 ± 0.28
Chloroform	1.46 ± 0.46	1.78 ± 0.42	1.54 ± 0.36	1.94 ± 0.38
Methanol	6.22 ± 0.50	8.58 ± 0.56	7.14 ± 0.62	9.22 ± 0.46
Water	5.48 ± 0.48	6.86 ± 0.46	5.84 ± 0.39	7.32 ± 0.52

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Fluorescence analysis

The fluorescence analysis of powdered sprouted grains in day light, short UV and long UV was examined by reported methods. The observations are given in **Table 2 & 3.** The powdered raw and sprouted grains of *P. glaucum* and *S. bicolor* were subjected to fluorescence analysis using different chemical reagents under visible light and ultraviolet light (254 nm and 366 nm). The powder exhibited characteristic fluorescence behaviour with distinct colour variations depending on the reagent used. These variations may be attributed to the presence of phytoconstituents and secondary metabolites formed or enhanced during sprouting.

Table 2: Fluorescence analysis of the powdered raw and sprouted grains of *P. glaucum*

Observation for powdered raw *P. glaucum* grains			
Reagent Used	**Day Light**	**UV 254nm**	**UV366nm**
Powder as such	Light brown	Purple	Violet
1M-HCl (Aqueous)	Dark Brown	Black brown	Dark brown
1M-NaOH (Aqueous)	Tan	Teal	Emerald green
1M-NaOH (Alcoholic)	Light brown	Light blue	Pale blue
H_2SO_4 (50%)	Brown	Black brown	Tan
HNO_3	Light pink	Pink	Rose
Iodine	Greyish blue	Brown	Dark grey
Observation for powdered sprouted *P. glaucum* grains			
Powder as such	Light brown	Dull brown	Brown
1M-HCl (Aqueous)	Pale yellow	Yellow	Bright yellow
1M-NaOH (Aqueous)	Bright yellow	Yellowish green	Green
1M-NaOH (Alcoholic)	Dark yellow	Dark yellow	Fluorescent green
H_2SO_4 (50%)	Dark brown	Brown	Blackish brown
HNO_3	Orange brown	Orange	Redish orange
Iodine	Blue-black	Brown	Dark brown

The powder treated with dilute hydrochloric acid showed pale yellow fluorescence, while sodium hydroxide (aqueous and alcoholic) produced yellowish-green fluorescence under UV light, suggesting the presence of phenolic compounds. Treatment with nitric acid resulted in orange fluorescence, indicating possible presence of flavonoid derivatives. These characteristic fluorescence responses provide diagnostic features useful for identification and standardization of sprouted *P. glaucum* and *S. bicolor* grains. The enhanced fluorescence intensity compared to unsprouted grains suggests biochemical changes during sprouting leading to increased formation of fluorescent phytoconstituents. Therefore, fluorescence analysis serves as a simple and reliable pharmacognostical tool for authentication and quality control of the powdered sprouted grains.

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Table 3: Fluorescence analysis of the powdered raw and sprouted grains of *S. bicolor*

Observation for powdered raw *S. bicolor* grains			
Reagent Used	**Day Light**	**UV 254nm**	**UV 366nm**
Drug powder	Light brown	Light yellow	Dark yellow
1M-HCl (Aqueous)	Dark Brown	Greenish Black	Green
1M-NaOH (Aqueous)	Tan	Teal color	Emerald green
1M-NaOH (Alcoholic)	Light brown	Light blue	Pale blue
H_2SO_4 (50%)	Light Brown	Brown	Tan
HNO_3	Redish orange	Orange	Redish brown
Iodine	Blue	Brown	Dark brown
Observation for powdered sprouted *S. bicolor* grains			
Drug powder	Creamish brown	Dull brown	Brown
1M-HCl (Aqueous)	Pale yellow	Yellow	Bright yellow
1M-NaOH (Aqueous)	Yellowish brown	Yellowish green	Green
1M-NaOH (Alcoholic)	Dark yellow	Bright green	Fluorescent green
H_2SO_4 (50%)	Dark brown	Brown	Blackish brown
HNO_3	Orange brown	Orange	Redish brown
Iodine	Brown	Dark brown	Brown

Phytochemical screening

Phytochemical screening of raw and sprouted grains shows the presence of bioactive compounds, like flavonoids, phenolics, reducing sugars and amino acids (Table 4). Sprouting improves the phytochemical terpenoids of both grains *S. bicolor* and *P. glaucum*, making both valuable for nutraceutical and functional food applications.

Table 4: Qualitative phytochemical analysis of methanol extracts of raw and sprouted *Pennisetum glaucum* and *Sorghum bicolor*

Plant constituents + Test reagent	**Raw *P. glaucum***	**Sprouted *P. glaucum***	**Raw *S. bicolor***	**Sprouted *S. bicolor***
1. Alkaloids	–	–	–	–
2. Reducing sugar	+	+	+	+
3. Cardiac glycoside	–	–	–	–
4. Saponin glycoside	–	–	–	–
5. Anthocyanidins	+	–	+	–
6. Flavonoids	+	+	+	+
7. Phenolic compounds	+	+	+	+
8. Phytosterol	+	–	–	–
9.Terpenoids	–	+	–	+
10. Amino acids	+	+	+	+
11. Fatty acids	+	–	+	+

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TLC fingerprints

There were three pink, and brown colour spot (R_F 0.25, 0.78 and 0.87) in *P. glaucum* and two black brown spot (R_F 0.54 and 0.88) *S. bicolor* were observed. The number of spots of TLC fingerprints is shown in **Fig. 5 (A & B).**

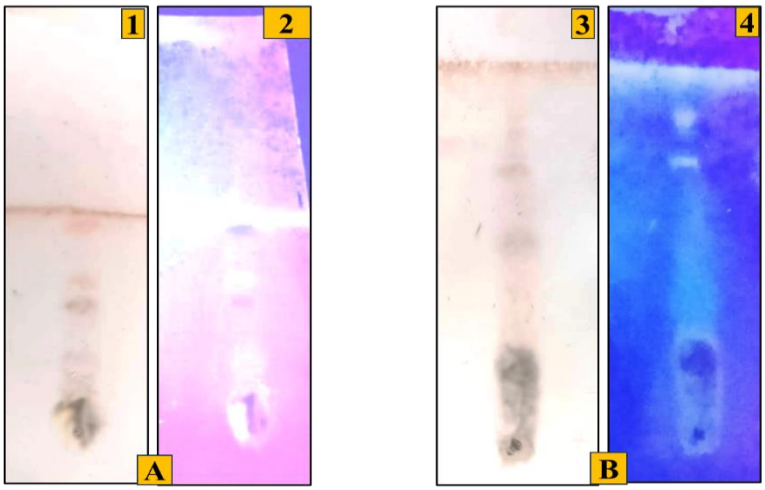


Fig. 5 TLC fingerprints of methanolic extract of (A: *S. bicolor* and B: *P. glaucum*)

Nutritional analysis

The nutritional analysis of sprouted *P. glaucum* and *S. bicolor* grains showed variations in moisture, protein, fat, and carbohydrate content, indicating biochemical modifications during the sprouting process. Sprouted *P. glaucum* exhibited an increase in protein content compared to raw grains, which may be attributed to enzymatic synthesis and mobilization of storage proteins during germination. Similarly, sprouted *S. bicolor* demonstrated a moderate rise in protein levels, reflecting enhanced amino acid availability. The carbohydrate content of both grains showed a slight reduction, possibly due to enzymatic breakdown of complex carbohydrates into simpler sugars utilized for seed metabolism. Dietary fiber content was found to increase in both sprouted grains, suggesting improved gastrointestinal benefits and better digestibility. The fat content showed a mild decrease in both samples, which could be due to lipase activity during germination. Ash values, representing total mineral content, were comparatively higher in sprouted samples, indicating enhanced mineral availability. Enhanced mineral content in sprouted grains may result from breakdown of anti-nutritional factors such as phytates, which otherwise bind minerals and reduce their bioavailability. The decrease in lipid content during sprouting indicates utilization of stored fats as energy sources for embryo growth.

Table 5: Proximate analysis of nutritional value of raw and sprouted *P. glaucum* and *S. bicolor* grains.

Parameters (per 100 g)	**Raw *P. glaucum***	**Sprouted *P. glaucum***	**Raw *S. bicolor***	**Sprouted *S. bicolor***
Moisture content (%)	5.16 ± 0.54	14.12 ± 0.56	6.22 ± 0.48	16.18 ± 0.46
Protein (%)	11.40 ± 0.26	13.60 ± 0.28	9.45 ± 0.25	11.80 ± 0.18
Fat (%)	4.80 ± 0.16	3.60 ± 0.20	3.10 ± 0.28	2.80 ± 0.22
Carbohydrate (%)	69.28 ± 0.64	64.53 ± 0.62	74.60 ± 0.82	67.20 ± 0.70
Total ash	6.50 ± 0.36	6.72 ± 0.42	7.24 ± 0.46	7.32 ± 0.48

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Acid insoluble ash	1.32 ± 0.18	1.12 ± 0.15	1.22 ± 0.16	0.98 ± 0.14
Water soluble ash	5.33 ± 0.32	5.64 ± 0.52	6.38 ± 0.36	6.72 ± 0.38
Crude fibre content	16.18 ± 0.62	16.72 ± 0.49	17.54 ± 0.72	17.82 ± 0.68

The reduction in carbohydrate contents after sprouting supports better glycemic control and suggests suitability for metabolic health. Increased dietary fiber contributes to improved digestion and absorption, aligning with Ayurvedic principles of Agni enhancement. The quantitative mineral analysis of sprouted *S. bicolor* and *P. glaucum* revealed the presence of appreciable amounts of essential minerals including calcium, iron, magnesium, potassium, phosphorus, sodium, and zinc. The results indicated that sprouting significantly enhanced the mineral availability in both grains when compared with their unsprouted forms. Among the analyzed minerals, potassium and phosphorus were found in higher concentrations in both sprouted grains. Sprouted *P. glaucum* showed comparatively higher levels of iron, calcium, and zinc, whereas sprouted *S. bicolor* exhibited higher magnesium and potassium contents. The increased mineral content observed after sprouting may be attributed to the activation of hydrolytic enzymes during germination, which reduces antinutritional factors such as phytic acid and tannins that normally bind minerals and decrease their bioavailability. The increased calcium and iron contents suggest that sprouted millets may serve as valuable dietary sources for bone health and prevention of iron deficiency anemia. Similarly, the elevated magnesium and potassium contents support their potential role in maintaining cardiovascular and neuromuscular functions. These findings support the traditional use of sprouted millets in health-promoting diets and suggest their possible application in nutraceutical and dietary supplement formulations.

Conclusion

Overall, the nutritional analysis demonstrates that sprouting significantly improves the nutrient density and bioavailability of *P. glaucum* and *S. bicolor*. These findings support their potential use as Dhātu-Poṣaka functional foods, capable of promoting strength, vitality, and tissue nourishment. Sprouted grains of both plants have gained importance as functional foods due to their enhanced nutritional value after germination. Sprouting of the grains enhances the bulk-promoting and strength promotion making them suitable Dhātu-Poṣaka foods. Sprouting of these grains, owing to enhanced bioavailability of nutrients and improved digestibility following germination, may serve as Dhātu-Poṣaka dietary components. Their balanced macronutrient and micronutrient composition supports sequential nourishment of Sapta Dhātu, thereby contributing to improved strength, vitality, and physiological homeostasis. Sprouting was found to improve mineral bioavailability due to the reduction of antinutritional factors such as phytates and tannins, which normally interfere with mineral absorption. The increased enzymatic activity during germination may have contributed to the release and better accessibility of bound minerals. Overall, the findings support the use of sprouted millets as economical and natural sources of essential minerals with potential health benefits. These sprouted grains may serve as promising dietary supplements and could be utilized in the development of nutraceutical and therapeutic food

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formulations aimed at improving nutritional status and preventing mineral deficiency-related disorders. Isolation of specific bioactive compounds responsible for pharmacological effects, development of sprouted millet nutraceuticals as functional foods and clinical trials for validation of therapeutic efficacy are the future prospects of the work.

Declarations

Conflict of Interest: The authors declare that they have no conflicts of interest related to this work.
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