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Standardisation and Nutritional Characterisation of Millet-based *Samsarjana Krama* Dietary Formulations: Integration of *Ayurvedic* Principles with Modern Food Technology

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Abstract

Background: *Samsarjana Krama*, the graduated post-*Shodhana* dietary regimen described in classical texts like the Charaka Samhita and *Ashtanga Hridayam*, offers a systematic protocol for dietary re-introduction during convalescence. Standardised, nutritionally validated modern formulations aligned with this framework remain limited, despite growing interest in millets as nutrient-dense functional foods. **Aim:** To develop, standardise, and nutritionally characterise four millet-based ready-to-cook/reconstitute formulations, *Peya*, *Vilepi*, *Akrita Yusha*, and *Krita Yusha,* aligned with *Samsarjana Krama* principles, using millets selected through multi-drying method optimisation. **Methods:** Eight millet varieties (Finger, Great, Pearl, Proso, Foxtail, Little, Barnyard, Browntop) were sprouted and subjected to oven, sun, and shade drying, then screened for proximate composition. Proso millet (highest carbohydrate: 70.04%) and Foxtail millet (highest protein: 11.74%) were selected for their compatibility with respective preparations. Twelve formulations (P1–P3, V1–V3, A1–A3, K1–K3) were developed using standardised processing soaking, sprouting, drying, roasting, dehulling, autoclaving, and freeze-thaw cycling and evaluated for proximate, mineral, and antinutrient composition. **Results:** *Krita Yusha* formulations showed the highest nutritional density, with protein ranging from 16.53–20.53 g/100 g, calcium up to 75.91 mg, and potassium up to 583.06 mg/100 g, attributed to synergistic contributions from Pippali, Turmeric, Ginger, Mustard, and Curry leaves. Antinutrient levels of phytates (288–525 mg), tannins (0.21–0.37 g), and oxalates (18.47–23.25 mg) remained within acceptable dietary safety thresholds across formulations. **Conclusion:** The standardised millet-based *Samsarjana Krama* formulations represent a validated, scalable, and nutritionally adequate modern adaptation of classical convalescent dietary protocols.

Major Findings: *Krita Yusha* formulations demonstrated the highest protein, calcium, and potassium content among all preparations, while antinutrients remained within safe limits, confirming the nutritional adequacy of these millet-based *Samsarjana Krama* formulations.

Keywords: *Ayurvedic* Dietary Regimen, Millet Formulations, Nutritional Characterisation, *Peya,* Process Standardisation, *Vilepi, Yusha*

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1. Introduction

Ayurveda, the ancient Indian system of medicine, offers a comprehensive framework for therapeutic nutrition that extends beyond mere dietary prescription. Among its most elegant clinical constructs is *Samsarjana Krama,* a graduated dietary regimen prescribed as part of the post-*Panchakarma* (*Shodhana*) management protocol to systematically restore digestive capacity (*Agni*) following eliminative therapies[1,2]. The regimen progresses sequentially through specific food preparations: *Peya* (thin rice gruel), *Vilepi* (thick gruel), *Akrita Yusha* (plain pulse soup), and *Krita Yusha* (spiced pulse soup), each representing an incremental increase in digestive demand[3]. Classical texts including Charaka Samhita (*Siddhisthana* 1/7), *Ashtanga Hridayam* (*Suttrasthana* 16), and Sushruta Samhita describe these preparations using *Shali* rice *(*a variety of red rice*)* as the primary cereal ingredient, selected for its lightness *(Laghu*), ease of digestibility, and *Tridosha*-balancing properties[4,5]. However, the modern food system presents an opportunity to enrich these time-honoured preparations with millets a group of nutrient-dense, gluten-free minor cereals increasingly recognized for their therapeutic potential in chronic disease management and nutritional rehabilitation[6]. Millets, particularly Proso (*Panicum miliaceum*) and Foxtail (*Setaria italica*), have been documented for their high protein, mineral, and dietary fibre content, alongside favourable glycaemic profiles[7]. Sprouting, a recognised bioprocessing technique, further enhances nutritional bioavailability by reducing phytates and improving amino acid profiles through enzymatic hydrolysis[8,9]. The drying method applied post-sprouting critically determines the retention of these nutritional gains, with oven, sun, and shade drying yielding differential proximate compositions. Despite growing academic interest in both *Ayurvedic* dietary systems and functional millet foods, no systematic study has documented the process standardisation, multi-variant formulation development, and comprehensive nutritional profiling of *Samsarjana Krama* preparations using sprouted millets. This study focuses on (i) evaluating the proximate composition of eight sprouted millet varieties under three drying conditions; (ii) selecting the best-performing millets for each *Samsarjana Krama* preparation; (iii) developing and standardising twelve millet-based *Samsarjana Krama* formulations across three compositional variants; and (iv) nutritionally characterising the optimised formulations by adopting modern Food Technology and *Ayurvedic* principles

2. Materials and Methods

2.1 Raw Material Procurement and Preparation

Eight millet varieties: Finger millet (*Eleusine coracana*), Sorghum (*Sorghum bicolor*), Pearl millet (*Pennisetum glaucum*), Proso millet (*Panicum miliaceum*), Foxtail millet (*Setaria italica*), Little millet (*Panicum sumatrense*), Barnyard millet (*Echinochloa frumentacea*), and Browntop millet (*Brachiaria ramosa*) were procured from Kanakapura Organic Producer Company, Yerandappanahalli Kodihalli Hobli, Kanakapura Taluk, Ramanagara, Karnataka, India. Red rice (*Oryza sativa* var. *indica*), green gram dhal (*Vigna radiata*), and spices (*Pippali*, turmeric, ginger, mustard, curry leaves, salt) were sourced from the local market in Davangere, Karnataka, India.

2.2 Sprouting and Drying Optimisation

All millet varieties were washed thoroughly, soaked for 10-12 hours at 25-27°C, and then subjected to sprouting for 60-74 hours at 27-30°C on moistened germination trays. Three drying methods were evaluated: (i) oven drying at 40±2°C for 8 hours, (ii) sun drying under sunlight conditions, and (iii) shade drying under ambient conditions away from direct light. Post-drying, all samples were pulverised using a hammer mill and stored in airtight containers at ambient temperature for proximate analysis.

2.3 Proximate Analysis of Sprouted Millets

Proximate composition, including moisture, carbohydrate (CHO), protein, crude fibre, fat, and ash, was determined for all sprouted-dried millet variants using standard AOAC methods[10]. Moisture content was estimated by the hot-air oven method (105°C to constant weight), crude protein by the Kjeldahl method (N × 6.25), crude fat by Soxhlet extraction, crude fibre by acid-alkali digestion, ash by muffle furnace incineration at 550°C, and carbohydrate by difference. All analyses were performed in triplicate and values expressed as mean ± SD per 100 g dry weight.

2.4 Millet Selection Criteria

Millet selection for *Samsarjana Krama* formulations was guided by alignment with classical *Ayurvedic* dietary properties and modern nutritional parameters. For *Peya* and *Vilepi* (gruel-based preparations requiring *Laghu* and easily digestible ingredients), Proso millet was selected based on its highest carbohydrate content (70.04 ± 0.05% in oven-dried variant) and relatively lower fibre (8.51 ± 0.14%), making it most suitable for early-stage convalescent gruels. For *Akrita Yusha* and *Krita Yusha* (pulse-soup-based preparations), Foxtail millet was selected based on its superior protein content (11.74 ± 0.11%), offering complementarity with green gram dhal in meeting convalescent protein requirements.

2.5 Formulation Development

Twelve formulations were developed across four *Samsarjana Krama* preparation categories. For each category, three formulation variants (labelled as -1, -2, -3) were prepared with progressively modified ingredient ratios to assess the effect of millet-to-complement ratio on nutritional outcome. *Peya* formulations (P-1, P-2, P-3) comprised Proso millet and Red Rice in ratios 20:80, 35:65, and 50:50, respectively. *Vilepi* formulations (V-1, V-2, V-3) used ratios 25:75, 40:60, and 55:45. *Akrita Yusha* formulations (A-1, A-2, A-3) combined Foxtail millet with Green gram dhal at ratios 25:75, 40:60, and 55:45. *Krita Yusha* formulations (K-1, K-2, K-3) included Foxtail millet, Green gram dhal, and standardized spice blends (*Pippali*, turmeric, salt, ginger, mustard, curry leaves) at pre-optimized proportions.

Standardised processing protocols were developed for each preparation type. *Peya* and *Vilepi* ingredients were sprouted, tray-dried at 40±2°C, and pulverised using a hammer mill to a particle size passing 100% through a 500-micron sieve (*Peya*) or 98% through a 212-micron IS sieve 70 mesh (*Vilepi*). *Vilepi* additionally underwent dry roasting at 70±2°C for 5-6 minutes to enhance aroma and flavour characteristics consistent with classical preparation descriptions[3]. *Akrita Yusha* and *Krita Yusha* formulations underwent a more complex processing sequence involving centrifugal dehulling of sprouted grains, autoclave pre-cooking at 15 psi for 10 minutes, freezing the cooked mixture at - 18°C for 10-12 hours, and subsequent microwave drying at 100 W until moisture content was reduced to approximately 8-10%. This freeze-thaw-dry sequence was employed to achieve an instant reconstitution

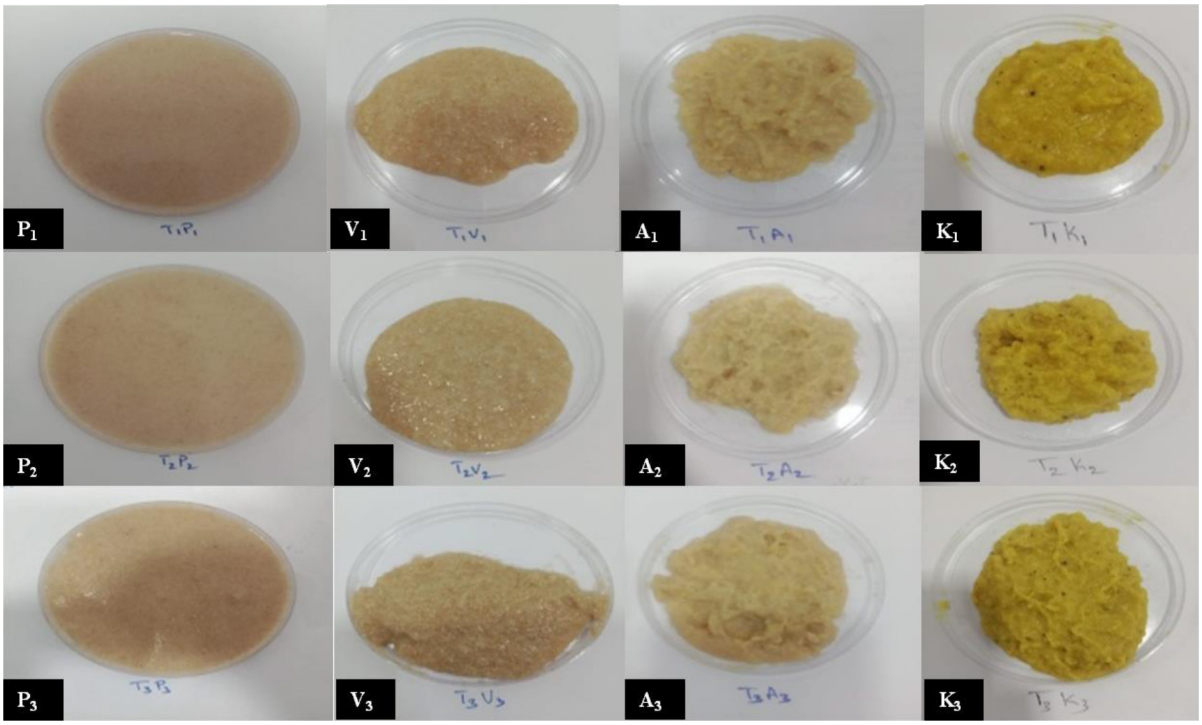


Figure 1. Different formulations of *Samsarjana krama* preparations.

product while preserving macronutrient integrity. *Krita Yusha* additionally incorporated pre-processed instant spice blends. All formulations were cooled to room temperature before packaging to prevent condensation. Cooked formulations are illustrated in Figure 1.

2.6 Reconstitution Specifications

Peya was standardised for cold reconstitution (20 g powder in 250 mL warm water) with a two-step hydration method: initial mixing with a small volume of hot water to prevent lump formation, followed by gradual addition of remaining water and 2-3 minutes of covered resting. *Vilepi, Akrita Yusha*, and *Krita Yusha* were standardised for hot cooking reconstitution (100 g in 580 mL boiling water, cooked for 10-12 minutes) to yield a thick gruel or mushy consistency appropriate for each stage of the *Samsarjana* sequence.

2.7 Nutritional Analysis of Formulations

Proximate composition of all twelve formulations was determined using AOAC 2016 standard methods. Mineral analysis of calcium, iron, phosphorus, magnesium, zinc, and potassium was performed by Atomic Absorption Spectrophotometry (AAS) following wet acid digestion[11]. Antinutrient analysis included phytates by the method of Haug and Lantzsch[12], tannins by the Folin-Ciocalteu vanillin method[13], and oxalates by the permanganate titration method[14]. All values are expressed as mean ± SD per 100 g on a dry weight basis, based on triplicate analysis.

3. Results and Discussion

3.1 Effect of Drying Method on Proximate Composition of Sprouted Millets

The proximate analysis of eight sprouted millet varieties under three drying methods (oven, sun, shade) revealed significant inter-variety and inter-method variation (Table 1). Oven drying at 40±2°C consistently yielded lower moisture content and comparatively better preservation of macronutrients. Proso millet demonstrated the highest carbohydrate content across all drying methods (oven: 70.04 ± 0.05%; sun: 69.90 ± 0.05%; shade: 69.08 ± 0.08%), confirming its suitability as the primary cereal for early-stage gruel preparations where digestible energy is a clinical priority. Foxtail millet recorded the highest protein content across all drying conditions (oven: 11.74 ± 0.11%; sun: 11.51 ± 0.15%; shade: 11.70 ± 0.08%), making it the preferred choice for *Yusha* preparations where post-*Shodhana* protein repletion is essential.

Oven drying was selected as the preferred method based on superior moisture control and operational reproducibility, consistent with reports by Nithya and Ramachandramurty[15], who demonstrated that controlled temperature drying better preserves essential amino acids in sprouted cereals compared to ambient drying methods. Barnyard millet exhibited the highest crude fibre content (oven: 13.20 ± 0.17%), while Foxtail and Pearl millet registered the highest fat content (4.34 ± 0.03% and 4.27 ± 0.02%, respectively). These characteristics rendered them less suitable for initial *Samsarjana* preparations, where classical texts emphasise *Laghu* (lightness) and *Snigdha* (unctuous) properties over calorie-dense profiles[3].

Table 1. Proximate composition of millet varieties

Millet	Moisture	CHO	Protein	Fiber	Fat	Ash
Finger Millet	11.51±0.01	66.55±0.28	7.18±0.04	11.23±0.06	1.46±0.07	2.07±0.03
Great Millet	10.53±0.01	67.68±0.17	8.44±0.11	10.27±0.05	1.72±0.03	1.35±0.04
Pearl Millet	8.89±0.15	65.59±0.06	8.37±0.31	11.51±0.05	4.27±0.02	1.37±0.01
Proso Millet	8.89±0.10	70.04±0.05	9.13±0.05	8.51±0.14	1.18±0.01	2.24±0.01
Foxtail Millet	10.26±0.09	62.73±0.06	11.74±0.11	8.58±0.06	4.34±0.03	2.35±0.03
Little Millet	13.70±0.13	65.52±0.09	8.69±0.06	7.68±0.05	2.56±0.01	1.85±0.04
Barnyard Millet	10.29±0.04	65.19±0.12	6.82±0.07	13.20±0.17	2.23±0.02	2.28±0.01
Browntop Millet	10.20±0.02	66.44±0.07	7.55±0.11	11.58±0.05	1.86±0.04	2.37±0.01

CHO: Carbohydrate. Values are presented as mean ± SD (n = 3) in percentage on a wet basis.

Table 2. Proximate composition of *samsarjana krama* formulations

Nutrient (per 100 g)	P-1	P-2	P-3	V-1	V-2	V-3	A-1	A-2	A-3	K-1	K-2	K-3
Moisture (%)	10.12±0.32	10.06±0.29	10.0 ±0.29	10.1 ±0.31	10.04±0.29	9.98 ±0.3	9.12 ±0.28	9.2±0.27	9.28 ±0.28	9.0±0.27	9.07±0.26	8.94 ±0.25
Energy (kcal)	347.4±3.15	346.2±2.87	345.0±2.83	347.0±3.04	345.8±2.83	344.6±2.87	338.25±2.86	340.8±2.77	343.35±2.93	333.76±2.7	335.88 ±2.63	331.53±2.66
Protein (g)	9.3±0.43	9.9±0.40	10.5±0.40	9.5±0.42	10.1±0.40	10.7 ±0.41	21.45 ±0.68	19.62±0.59	17.79 ±0.54	20.53±0.64	19.31 ±0.58	16.53 ±0.49
Fat (g)	2.78±0.18	2.92±0.17	3.05±0.18	2.83±0.17	2.96±0.17	3.1± 0.18	1.97 ±0.12	2.44 ±0.15	2.91 ±0.18	2.24 ±0.12	2.53 ±0.13	3.3 ±0.17
Carbohydrate (g)	71.0±1.35	70.25±1.24	69.5±1.23	70.75±1.3	70.0±1.22	69.25±1.25	58.33 ±1.41	59.3 ±1.34	60.28 ±1.40	57.34±1.33	58.14 ±1.28	57.66 ±1.26
Crude Fiber (g)	1.88±0.13	1.94±0.12	2.0±0.12	1.9±0.12	1.96±0.12	2.02 ±0.12	4.75 ±0.27	5.14 ±0.27	5.53 ±0.30	4.93 ±0.25	5.24 ±0.26	5.71 ±0.27
Ash (g)	1.6±0.08	1.68±0.08	1.75±0.08	1.62±0.08	1.70±0.08	1.78 ±0.08	3.45 ±0.15	3.42 ±0.14	3.39 ±0.15	4.85 ±0.14	4.64 ±0.13	6.86 ±0.13

Values are Mean ± SD (n = 3). P: *Peya*; V: *Vilepi*; A: *Akrita Yusha*; K: *Krita Yusha*

3.2 Proximate Composition of *Samsarjana Krama* Formulations

The proximate composition of all twelve formulations is presented in Table 1. *Peya* and *Vilepi* formulations (P and V series) demonstrated comparable moisture contents ranging from 9.98-10.12%, moderate protein (9.3-10.7 g/100 g), and higher carbohydrate contents (69.25-71.0 g/100 g), consistent with their intended role as energy-providing thin gruels in the early stages of *Samsarjana Krama*. Across P-1 to P-3, protein increased proportionally with increasing Proso millet content (9.3 to 10.5 g/100 g), while carbohydrates showed a modest decline (71.0 to 69.5 g/100 g), reflecting the higher protein content of Proso relative to red rice.

Akrita Yusha and *Krita Yusha* formulations (A and K series) exhibited markedly higher protein content (16.53-21.45 g/100 g), substantially elevated mineral content, and lower carbohydrate values (57.34–60.28 g/100 g), attributable to the high-protein green gram dhal component. Formulation A-1 (Foxtail: Green gram = 25:75) showed the highest protein among *Akrita Yusha* variants (21.45 ± 0.68 g/100 g), declining progressively as the millet-to-dhal ratio increased in A-2 (19.62 g) and A-3 (17.79 g). The energy density across all formulations ranged between 331.53–347.4 kcal/100 g, appropriate for convalescent dietary requirements which necessitate moderate, easily metabolizable caloric delivery.

The crude fibre content was notably higher in *Yusha* formulations (4.75–5.71 g/100 g) compared to *Peya* and *Vilepi* (1.88–2.02 g/100 g), a progression that aligns well with *Samsarjana Kram's* graduated dietary reintroduction principle beginning with minimally fibrous preparations to gently stimulate digestive *Agni*, progressively introducing fibre as digestive capacity is restored[3,16]. Ash content in *Krita Yusha* formulations (4.64–6.86 g/100 g) was the highest across all groups, reflecting the mineral-rich contribution of the incorporated spices.

3.3 Mineral Composition

Mineral analysis (Table 3) revealed that *Krita Yusha* formulations were the most mineral-dense across all parameters. Calcium content ranged from 12.4 mg/100 g in P-1 (*Peya*) to a maximum of 75.91 mg/100 g in K-1 (*Krita Yusha*), with the K series demonstrating superior calcium values compared to the A series despite similar cereal-legume bases. This enhancement in *Krita Yusha* is attributable to the calcium-rich spice profile of curry leaves (840 mg/100 g calcium), Ginger, and Pippali (*Piper longum*) incorporated in the spice blend[17].

Iron content was highest in *Krita Yusha* formulations (4.39-4.48 mg/100 g), followed by *Akrita Yusha* (3.52-4.0 mg/100 g), with *Peya* and *Vilepi* formulations recording 2.26–2.54 mg/100 g. Potassium values in *Krita Yusha* (485.97–583.06 mg/100 g) and *Akrita Yusha* (439.0–565.0 mg/100 g) were markedly higher than *Peya/Vilepi* formulations (183–188 mg/100 g), reflecting the high potassium content of green gram dhal (983 mg/100 g)[18]. Magnesium content was highest in A-1 (162.0 ± 6.22 mg/100 g), consistent with Foxtail millet's documented magnesium content[19]. Phosphorus

Table 3. Mineral composition of all *samsarjana krama* formulations

Mineral (per 100 g)	P-1	P-2	P-3	V-1	V-2	V-3	A-1	A-2	A-3	K-1	K-2	K-3
Calcium (mg)	12.4 ±0.8	12.7 ±0.75	13.0 ±0.77	12.5 ±0.77	12.8 ±0.75	13.1 ±0.79	64.0 ±3.21	57.4 ±2.7	50.8 ±2.31	75.91 ±3.02	70.63 ±2.67	75.72 ±2.15
Iron (mg)	2.26 ±0.15	2.38 ±0.14	2.5 ±0.14	2.3 ±0.15	2.42 ±0.14	2.54 ±0.15	4.0 ±0.27	3.76 ±0.23	3.52 ±0.21	4.48 ±0.25	4.3 ±0.23	4.39 ±0.19
Phosphorus (mg)	169.2 ±5.24	176.1 ±5.01	183.0 ±5.26	171.5 ±5.11	178.4 ±5.04	185.3 ±5.44	317.0 ±10.51	311.6 ±9.26	306.2 ±8.65	309.17 ±9.86	305.17 ±9.0	292.37 ±7.79
Magnesium (mg)	94.8 ±3.44	98.4 ±3.23	102.0 ±3.31	96.0 ±3.34	99.6 ±3.22	103.2 ±3.40	162.0 ±6.22	145.8 ±5.15	129.6 ±4.24	158.04 ±5.82	147.31 ±5.1	126.65 ±3.8
Zinc (mg)	1.76 ±0.13	1.73 ±0.11	1.7 ±0.11	1.75 ±0.12	1.72 ±0.11	1.69 ±0.11	2.77 ±0.19	2.70 ±0.16	2.62 ±0.15	2.75 ±0.18	2.70 ±0.16	2.58 ±0.14
Potassium (mg)	183.0 ±5.43	185.25 ±5.03	187.5 ±5.08	183.75 ±5.25	186.0 ±4.99	188.25 ±5.19	565.0 ±16.67	502.0 ±13.74	439.0 ±11.19	583.06 ±15.61	542.98 ±13.65	485.97 ±10.16

Values are Mean ± SD (n = 3). All mineral values are in mg/100 g.

values were greatest in *Akrita Yusha* A-1 (317.0 ± 10.51 mg/100 g), which corresponded to the highest green gram dhal proportion (75%).

These mineral profiles acquire clinical significance in the context of *Samsarjana Krama's* therapeutic objectives. Post-Panchakarma patients often demonstrate electrolyte imbalances and mineral deficiencies following eliminative therapies. The progressive introduction from low-mineral *Peya/Vilepi* to high-mineral *Krita Yusha* mirrors a physiologically rational mineral repletion gradient, allowing the recovering gut to progressively adapt to increasing mineral loads without precipitating osmotic stress[2,20].

3.4 Antinutrient Profile

The antinutrient concentrations of all formulations are presented in Table 4. Phytate content ranged from 288 mg/100 g (P-1) to 525 mg/100 g (A-1), with values proportional to the green gram dhal content in the formulations. The sprouting process employed in this study has been documented to reduce phytate content by 25–50% compared to raw grains, through phytase enzyme activation[8,21]. The phytate values in all formulations remain below the reported threshold of concern (>750 mg/100 g) for mineral absorption inhibition in a balanced diet[22].

Tannin content was uniformly low across all formulations (0.21-0.37 g/100 g), with *Krita Yusha* formulations recording marginally higher values (0.33–0.37 g) attributable to tannin contributions from Pippali and Turmeric. However, these levels are well within the generally recognised safe range of < 2 g/100 g for food applications[23]. Turmeric's curcumin, while slightly contributing to tannin quantification by some colourimetric methods, concurrently provides anti-inflammatory and digestive stimulant properties that complement the therapeutic aims of *Krita Yusha*[24].

Oxalate content across all formulations remained low (18.47–23.25 mg/100 g), with no significant difference between preparation types. These values are substantially below the dietary oxalate threshold of concern (250 mg/serving), posing no risk of oxalate-related nephrolithiasis in the convalescent population for whom *Samsarjana Krama* is prescribed[25]. Collectively, the antinutrient profile of these formulations is consistent with safety and supports adequate mineral bioavailability when consumed as part of a graduated post-*Shodhana* regimen.

3.5 Alignment with Classical *Ayurvedic* Properties and Clinical Relevance

From an *Ayurvedic* perspective, the selection of Proso millet for Peya and Vilepi is consistent with the *Shali* rice substitution principle, as both share *Laghu* (light), *Sheeta* (cool), and *Madhura* (sweet) Rasa properties, minimally challenging the *Mandagni* (weakened digestive fire) typical of the post-Shodhana state[3,26]. Foxtail millet (*Kanguni* in *Ayurvedic* materia medica, referenced in Bhavaprakasha *Nighantu*) is classified as *Kashaya-Madhura* (astringent-sweet), *Laghu*, and *Grahi* (absorbent), properties directly aligned with the therapeutic intent of *Yusha* preparations in restoring gut mucosal integrity[27].

The spice blend in *Krita Yusha Pippali* (*Piper longum*), *Shunti* (ginger), *Haridra* (turmeric), *Sarshapa* (mustard), and *Nimba patra* (curry leaves) corresponds precisely with classical *Dipaniya* (digestive stimulant) and *Pachana* (digestive) herb categories described in Charaka Samhita's *Dipaniya Mahakashaya*[4]. Their incorporation in the final stage of *Samsarjana Krama* reflects the classical logic of progressively stimulating enzymatic digestive secretions as the post-*Shodhana* gut recovers. The validated nutritional data confirm that these spices concomitantly enhance the mineral

Table 4. Antinutrient profile of all *samsarjana krama* formulations

Antinutrient (per 100 g)	P-1	P-2	P-3	V-1	V-2	V-3	A-1	A-2	A-3	K-1	K-2	K-3
Phytates (mg)	288 ±12.71	294 ±11.81	300 ±11.97	290 ±12.3	296 ±11.74	302 ±12.26	525 ±22.12	510 ±19.38	495 ±17.94	506.55 ±20.75	496 ±18.87	462.55 ±16.13
Tannins (g)	0.23 ±0.02	0.22 ±0.02	0.21 ±0.02	0.22 ±0.02	0.22 ±0.02	0.21 ±0.02	0.32 ±0.03	0.34 ±0.02	0.36 ±0.03	0.33 ±0.02	0.34 ±0.02	0.37 ±0.02
Oxalates (mg)	20.8 ±1.54	21.4 ±1.41	22.0 ±1.40	21.0 ±1.48	21.6 ±1.39	22.2 ±1.42	18.75 ±1.26	21.0 ±1.40	23.25 ±1.66	18.47 ±1.20	19.98 ±1.29	21.86 ±1.51

Values are Mean ± SD (n = 3). Phytates and oxalates in mg/100 g; tannins in g/100 g

density, particularly calcium (up to 75.91 mg in K-1) and iron (up to 4.48 mg in K-1), supporting haematopoietic recovery often compromised post-*Vamana* and *Virechana* therapies[2,5].

The process standardisation parameters developed in this study, particularly the autoclave-freeze-microwave drying sequence for *Yusha* preparations, offer a significant advancement over traditional open-fire preparation methods, providing controlled, reproducible, pathogen-safe products while preserving the essential nutritional and organoleptic characteristics of the classical preparations. Particle size standardisation (98-100% passing through 212-500 µm sieves) ensures consistent reconstitution behaviour and texture, critical for palatability acceptance in the clinically vulnerable convalescent patient population.

4. Conclusion

This study presents the first systematic documentation of process standardisation and nutritional characterisation of millet-based *Samsarjana Krama* dietary formulations integrating *Ayurvedic* principles with modern food technology. The selection of Proso millet for gruel preparations and Foxtail millet for pulse-soup preparations, based on multi-drying proximate optimisation, was validated as nutritionally rational and classically aligned. The twelve optimised formulations demonstrated a progressive nutritional gradient from *Peya* through *Krita Yusha*, mirroring the graduated digestive stimulation principles of *Samsarjana Krama*. *Krita Yusha* formulations, particularly K-1, provided the highest mineral density while maintaining acceptable antinutrient levels, supporting their role in the convalescent mineral and protein repletion phase. The standardised processing protocols including sprouting, drying, roasting, centrifugal dehulling, autoclaving, freeze-thaw cycling, and microwave drying provide scalable, reproducible manufacturing parameters for commercial or institutional production of validated *Ayurvedic* convalescent foods. Future studies should evaluate the sensory acceptability, glycaemic index, *in vitro* digestibility, and clinical efficacy of these formulations in post-*Panchakarma* patients to complete the translational evidence base for their therapeutic application.

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Author Contribution

Conceptualization was done by S. O. Sadashiv and Shashidhar H. Doddamani; methodology was the responsibility of Ajaykumar M., and S. O. Sadashiv; validation was done by Ajaykumar M., Sharangouda J. Patil., and S. O. Sadashiv.; investigation was done by Ajaykumar M.; original draft writing was done by Ajaykumar M., review and editing were done by Sharangouda J. Patil and S. O. Sadashiv; supervision was taken care of S. O. Sadashiv; and project administration was looked by Sharangouda J. Patil and S. O. Sadashiv. All authors have read and agreed to the published version of the manuscript.