

Development, Nutritional Evaluation and Organoleptic Assessment of *Shramahara Mahakashaya*-Based Ragi Saktu: An Ayurvedic Functional Food

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ABSTRACT

Background: *Shramahara Mahakashaya* is an Ayurvedic formulation traditionally indicated for alleviating physical exhaustion and promoting strength. However, its application in a standardized, nutritionally enriched functional-food preparation requires systematic evaluation.

Objective: To develop a *Shramahara Mahakashaya*-based Ragi Saktu and evaluate its physicochemical properties, nutritional composition, analytical safety, chromatographic characteristics, and organoleptic acceptability.

Materials and Methods: Three trial batches of *Shramahara Mahakashaya*-based Ragi Saktu were prepared using Ragi (*Eleusine coracana*) as the principal cereal ingredient, together with selected ingredients described in the classical Ayurvedic formulation. Khandsari sugar was substituted for Ikshu. The final formulation was selected based on organoleptic characteristics and subjected to physicochemical, nutritional, heavy-metal, aflatoxin, and high-performance thin-layer chromatography (HPTLC) analyses. Sensory acceptability was assessed among 27 participants using a 5-point hedonic scale. Descriptive statistics were used to summarize sensory responses.

Results: Batch III was selected as the final formulation based on its sensory characteristics. The product demonstrated an energy value of 399.64 kcal/100 g, carbohydrate content of 78.97 g/100 g, protein content of 6.72 g/100 g, fat content of 6.32 g/100 g, and dietary fibre content of 12.95 g/100 g. Calcium and folic acid concentrations were 1263.472 mg/kg and 2.298 mg/kg, respectively. Overall sensory acceptability was 4.63 ± 0.49 , with the highest mean score for aroma (4.89 ± 0.42). Arsenic, cadmium, and mercury were below their respective limits of quantification, while lead was detected at 0.403 mg/kg. All analysed aflatoxins were below their respective limits of quantification. HPTLC fingerprinting demonstrated characteristic bands corresponding to selected phytochemical markers.

Conclusion: The developed Shramahara Mahakashaya-based Ragi Saktu demonstrated favourable sensory acceptability, appreciable nutritional value, and satisfactory analytical safety findings in the tested batch. Further studies assessing microbiological quality, storage stability, and clinical outcomes are warranted before its anti-fatigue efficacy can be established.

Keywords: Anti-fatigue property, *Ahara Kalpana*, *Balya* and *Brimhana*, Finger millet (*Eleusine coracana*), Hedonic scale, Organoleptic evaluation, *Shrama*, *Shramahara Mahakashaya*.

1. INTRODUCTION

Fatigue is a multifactorial condition characterized by diminished physical performance, reduced endurance, and a persistent feeling of tiredness, which adversely affects daily activities and quality of life. Modern lifestyle practices, irregular dietary habits, nutritional deficiencies, psychological stress, and prolonged physical exertion have contributed to the increasing prevalence of fatigue among individuals of all age groups. Consequently, there is growing interest in nutritionally enriched functional foods that not only provide nourishment but also improve physical performance and overall well-being.

Ayurveda emphasizes the maintenance of health through appropriate dietary practices and considers *Ahara* as one of the three fundamental pillars (*Trayopastambha*) [1] of life. Among the fifty *Mahakashayas* described by *Acharya Charaka*, *Shramahara Mahakashaya* is specifically indicated for alleviating *Shrama* (physical exhaustion) and restoring strength. The formulation comprises drugs such as *Draksha* (*Vitis vinifera*), *Kharjura* (*Phoenix dactylifera*), *Priyala* (*Buchanania lanzan*), *Badara* (*Ziziphus mauritiana*), *Dadima* (*Punica granatum*), *Parushaka* (*Grewia asiatica*), *Phalgu* (*Ficus carica*), *Yava* (*Hordeum vulgare*), *Shashtika Shali* (*Oryza sativa*), and *Ikshu* (*Saccharum officinarum*). [2] These ingredients are traditionally recognized for their *Balya*, *Brimhana*, *Tarpana*, and *Shramahara* properties, making them suitable for replenishing energy and supporting physical vitality.

Among the various Ayurvedic dietary preparations, *Saktu* occupies a unique

position as a roasted cereal-based formulation valued for its ease of preparation, prolonged shelf life, digestibility, and instant nourishing effect. Traditionally prepared from roasted cereals such as barley, *Saktu* has long been consumed as a wholesome dietary preparation capable of providing sustained energy and promoting health. [3] Classical Ayurvedic texts describe *Saktu* as *Sadya Tarpana* (providing immediate nourishment) [4] *Sadya Balakara* (instant strength promoting), *Laghu* (light to digest), [3] and *Hridya* (beneficial for the heart). [5] In the present study, the classical concept of *Saktu* was modified by incorporating Ragi (*Eleusine coracana*), a nutrient-dense millet known for its high calcium content, dietary fibre, essential amino acids, and low glycaemic index. Ragi has gained considerable attention as a functional food ingredient because of its nutritional richness and potential role in preventing lifestyle-related disorders. [6]

Combining Ragi with the drugs of *Shramahara Mahakashaya* provided an opportunity to develop a scientifically standardized Ayurvedic nutraceutical that integrates traditional therapeutic principles with contemporary nutritional science.

Therefore, the present study was undertaken to develop a *Shramahara Mahakashaya*-based Ragi *Saktu* through successive trial batches with varying ingredient proportions, and to select the most acceptable formulation on the basis of organoleptic evaluation. The selected final formulation was subsequently evaluated for its physicochemical characteristics, nutritional composition, fatty acid profile, amino acid

profile, safety parameters, and sensory acceptability. The study aims to provide scientific evidence supporting the utilization of this classical Ayurvedic concept in the development of modern functional foods suitable for promoting strength, reducing fatigue, and improving nutritional health.

2. MATERIALS & METHODS

2.1 Study Design

The present experimental study was undertaken to develop a nutritionally enriched Ayurvedic functional food based on the concept of *Shramahara Mahakashaya* incorporating Ragi (*Eleusine coracana*). Different trial batches were prepared by varying the proportions of ingredients, and the final formulation was selected on the basis of organoleptic acceptability. The selected formulation was subsequently subjected to comprehensive nutritional, physicochemical, safety, chromatographic, and sensory evaluation.

2.2 Selection of Raw Materials

The formulation was developed using the drugs described under *Shramahara Mahakashaya* in *Charaka Samhita* along with Ragi (*Eleusine coracana*) as the principal cereal ingredient. The selected ingredients included *Draksha* (*Vitis vinifera*), *Kharjura* (*Phoenix dactylifera*), *Priyala* (*Buchanania lanzan*), *Badara* (*Ziziphus mauritiana*), *Dadima* (*Punica granatum*), *Parushaka* (*Grewia asiatica*), *Phalgu* (*Ficus carica*), *Yava* (*Hordeum vulgare*), *Shashtika Shali* (*Oryza sativa*), and Ragi (*Eleusine coracana*). In the finalized formulation, *Khandsari* sugar was used as a substitute for *Ikshu* to improve practicality and product acceptability while preserving the classical concept.

All raw materials were procured from authenticated sources and were cleaned to remove extraneous matter before processing.

2.3 Formulation Development

The formulation was developed through multiple experimental batches by modifying

the proportion of individual ingredients to obtain optimum organoleptic characteristics without altering the basic concept of *Shramahara Mahakashaya*.

Each batch was evaluated for appearance, colour, aroma, taste, texture, consistency, ease of reconstitution, and overall acceptability. Based on the observations, minor changes were made in the ingredient proportions in subsequent batches. The batch with the most acceptable organoleptic characteristics was selected as the final formulation.

2.4 Preparation of Roasted Grain Flours

Ragi (*Eleusine coracana*), Yava (*Hordeum vulgare*) and *Shashtika Shali* (*Oryza sativa*) were procured from the local market of Jodhpur, Rajasthan. Each grain (2 kg) was manually cleaned to remove dust, stones, broken grains and other foreign matter, followed by washing with potable water 2–3 times. The washed grains were shade-dried and subsequently sun-dried until complete removal of surface moisture. Each grain was roasted separately in a stainless-steel vessel over medium flame with continuous stirring for approximately 20 min until a characteristic roasted aroma developed and light brown colour was attained. The roasted grains were cooled to room temperature, pulverized separately and passed through Sieve No. 85 to obtain uniformly sized flour. The prepared flours were stored in clean, dry, airtight containers until further use.

The yield of roasted flour was 93.5% for Yava, 95.5% for *Shashtika Shali* and 92.0% for Ragi.

2.5 Preparation of Individual Ingredients

2.5.1 Preparation of *Badara* Powder

Commercially available *Badara* powder was procured from the local market, examined for foreign matter and passed through Sieve No. 85 to obtain a fine and uniform powder.

2.5.2 Preparation of *Dadima* Powder

As fresh *Dadima* fruits were not used in the formulation, commercially available dried pomegranate seeds (*Anardana*) were

procured from the local market. The dried material was pulverized using a mixer grinder and passed through Sieve No. 85. The final yield of *Dadima* powder was 87.6% (438 g from 500 g).

2.5.3 Preparation of *Parushaka* Powder

Due to the non-availability of fresh *Parushaka* fruits, frozen fruits procured from the local market were used. The fruits were allowed to attain room temperature and ground to obtain a homogeneous paste. The paste was spread as a thin layer on clean stainless-steel trays and shade-dried. During drying, intermittent grinding was performed to break lumps and facilitate uniform moisture removal. This process was repeated until complete drying, after which the material was pulverized and passed through Sieve No. 85. The final yield was 54% (540 g from 1000 g).

2.5.4 Preparation of *Khandsari* Sugar Powder

Khandsari sugar was used as a substitute for *Ikshu* in the present formulation. The sugar was pulverized, passed through Sieve No. 85 and stored separately. The final yield was 95.6% (956 g from 1000 g).

2.5.5 Preparation of *Draksha*, *Kharjura*, *Phalgu* and *Priyala*

Dried *Draksha* (raisins), *Kharjura* (dates), *Phalgu* (fig) and *Priyala* kernels were inspected and cleaned. The materials were cut into small pieces using a clean stainless-steel knife. *Kharjura* and *Phalgu* were deseeded wherever applicable. The processed materials were retained as small pieces for incorporation into the formulation. The respective yields obtained were 78% for *Draksha*, 63% for *Kharjura*, 94% for *Phalgu* and 95% for *Priyala*.

2.6 Preparation of Shramahara Mahakashaya-Based Ragi Saktu

The formulation was developed based on the Ayurvedic concept of *Saktu Kalpana*, incorporating selected drugs of *Shramahara Mahakashaya* along with Ragi, Yava and *Shashtika Shali* flours. The ingredients were weighed according to the finalized formulation and thoroughly mixed in a clean stainless-steel vessel. The blended material was subjected to final grinding to facilitate uniform incorporation of the fruit and kernel components. The prepared *Saktu* was mixed thoroughly to obtain a homogeneous formulation.

Table 1: Composition of the *Saktu* Formulation

Ingredient	Batch I (g)	Batch II (g)	Batch III (g)
<i>Draksha</i>	10	10	50
<i>Kharjura</i>	10	10	50
<i>Priyala</i>	10	10	50
<i>Badara</i>	10	10	50
<i>Dadima</i>	10	10	50
<i>Phalgu</i>	10	10	50
<i>Parushaka</i>	10	10	50
<i>Khandsari</i> Sugar*	10	10	100
Yava flour	20	10	50
<i>Shashtika Shali</i> flour	20	10	50
Ragi flour	20	10	50

**Khandsari* sugar was used as a substitute for *Ikshu* due to the non-availability of the classical ingredient in a suitable form for formulation.

2.7 Packaging and Storage

The prepared *Shramahara Mahakashaya*-based Ragi *Saktu* was transferred into clean, dry, airtight, food-grade containers and stored at room temperature in a dry place until further evaluation.

2.8 Analytical Evaluation

The developed *Shramahara Mahakashaya*-based Ragi *Saktu* was subjected to systematic analytical evaluation to assess its organoleptic, physicochemical, nutritional, safety and chromatographic characteristics.

The analysis was carried out on the finalized *Saktu* preparation following standard laboratory procedures.

The nutritional, physicochemical, mineral, vitamin, amino acid, lipid profile, heavy metal and aflatoxin analyses were performed at Cultivator Phyto Lab Pvt. Ltd., Jodhpur, while Loss on Drying and High-Performance Thin Layer Chromatography (HPTLC) analysis were carried out at the Drug Testing Laboratory (DTL), Post Graduate Institute of Ayurveda (PGIA), Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur.

2.8.1. Organoleptic Evaluation

The sensory acceptability of the finalized *Shramahara Mahakashaya*-based Ragi *Saktu* was evaluated among 27 voluntary participants comprising teaching faculty and postgraduate scholars of the Department of Rasashastra and Bhaishajya Kalpana, Post Graduate Institute of Ayurveda, Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur. The participants were 27–60 years of age and included 9 males and 18 females. No specific disease-related inclusion or exclusion criteria were applied; participation was voluntary and limited to the available teaching faculty and postgraduate scholars of the department.

For sensory evaluation, 10 g of the finalized *Saktu* formulation was dissolved in 100 mL of potable water and served individually in clean glasses. The prepared sample was served at room temperature (approximately 28°C) in an air-conditioned room. As only the finalized formulation was evaluated, no comparative samples were presented, and sample coding, blinding, or randomization of sample presentation was not performed. Participants were instructed to cleanse their palate with water before tasting the sample. The preparation was evaluated for appearance and colour, texture/mouthfeel, taste/flavour, aroma/smell, crispness/consistency, and overall acceptability using a structured sensory evaluation form. A 5-point Hedonic Scale was used, where 5 = Like Extremely, 4 =

Like Moderately, 3 = Neither Like nor Dislike, 2 = Dislike Moderately, and 1 = Dislike Extremely. Individual responses were recorded and summarized as mean $\pm$ standard deviation (SD), along with the number and percentage of participants in each response category. [7]

Ethical approval for the sensory evaluation was obtained from the Institutional Ethics Committee of Post Graduate Institute of Ayurveda, Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur, vide approval number DSRRAU/PGIA/IEC/23-24/756, dated 03/01/2025. Participation was voluntary, and informed consent was obtained from the participants prior to sensory evaluation.

2.8.2. Physicochemical Evaluation

Determination of pH

The pH of the *Saktu* preparation was determined potentiometrically using a calibrated digital pH meter fitted with a glass electrode. Standard buffer solutions were used for calibration, and the pH of the sample was measured at room temperature.

Determination of Loss on Drying

Loss on Drying (LOD) was determined by drying a representative quantity of the powdered sample at the specified temperature until constant weight was obtained. The percentage loss in weight was calculated and expressed as percentage w/w.

2.8.3 Nutritional Analysis

The developed *Shramahara Mahakashaya*-based Ragi *Saktu* was analysed for the following nutritional parameters using standard analytical methods:

- **Protein:** determined by the Kjeldahl method.
- **Fat:** determined by Soxhlet extraction.
- **Total sugar:** determined by the Lane–Eynon titrimetric method.
- **Energy value:** calculated using Atwater conversion factors.
- **Carbohydrate:** determined by difference.
- **Dietary fibre:** estimated by the enzymatic-gravimetric method according to AOAC Official Method 985.29.

- **Calcium:** determined by Inductively Coupled Plasma–Mass Spectrometry (ICP-MS) following acid digestion.
- **Folic acid (Vitamin B9):** determined by LC-MS/MS.
- **Amino acid profile:** determined by HPLC following acid hydrolysis and pre-column derivatization.
- **Fatty acid profile:** determined by GC-FID after conversion of lipids into fatty acid methyl esters (FAMES).
- **Saturated fatty acids (SFA):** estimated as part of the fatty acid profile.
- **Trans fatty acids:** estimated as part of the fatty acid profile.
- **Total amino acids:** calculated from the quantified individual amino acids.

2.8.4. Safety Evaluation

Heavy Metal Analysis

Arsenic, cadmium, lead and mercury were determined by ICP-MS following acid digestion of the samples. The concentrations were expressed in mg/kg and compared with applicable permissible limits.

Aflatoxin Analysis

Aflatoxins B₁, B₂, G₁ and G₂ were determined by LC-MS/MS. The samples were extracted using an appropriate organic solvent followed by dispersive clean-up and

membrane filtration prior to instrumental analysis. The concentration of individual aflatoxins and total aflatoxins was determined against certified reference standards.

2.8.5. HPTLC Fingerprint Analysis

HPTLC fingerprinting was performed for chromatographic characterization of the developed preparations. Methanolic extracts of the samples were applied on precoated silica gel 60 F₂₅₄ plates using a CAMAG Linomat 5 applicator.

The plates were developed using suitable mobile phases selected for the respective marker compounds. After development, the plates were visualized under white light and UV radiation at appropriate wavelengths. Where required, derivatization was carried out using anisaldehyde–sulphuric acid reagent. Chromatographic fingerprints were documented using a CAMAG TLC Scanner and VisionCATS software. Characteristic bands were evaluated on the basis of their R_f values and comparison with corresponding reference markers.

2.8.6. Summary of Analytical Parameters

The analytical parameters evaluated in the present study are summarized below:

Category	Parameters
Organoleptic	Appearance, colour, aroma/odour, taste, texture, consistency, overall acceptability
Physicochemical	pH, Loss on Drying
Nutritional	Protein, fat, total sugar, energy value, carbohydrate, dietary fibre, calcium, folic acid (Vitamin B9), fatty acid profile, and amino acid profile.
Safety	Arsenic, cadmium, lead, mercury, aflatoxin B ₁ , B ₂ , G ₁ , G ₂ and total aflatoxins
Chromatographic	HPTLC fingerprint profile

2.8.7. Statistical Analysis

The sensory-evaluation data were analyzed descriptively using Microsoft® Excel® 2021 MSO (Version 2607, Build 16.0.20228.20124; 64-bit). For each sensory attribute, the number of participants selecting each response category was calculated and expressed as frequency (n) and percentage (%). The sensory scores were summarized as mean ± standard deviation (SD). As the present study was limited to descriptive evaluation of the finalized formulation, no inferential

statistical tests or hypothesis testing were performed.

RESULT

Three trial batches of *Shramahara Mahakashaya*-based Ragi Saktu were developed during the formulation process. Among the three trial batches, Batch III was selected as the final formulation based on its comparatively better sensory characteristics, particularly taste and appearance. Batch III exhibited the most desirable taste and visually acceptable appearance and was

therefore selected for further evaluation. Accordingly, the organoleptic, physicochemical, nutritional, safety, and HPTLC results presented in the following

sections correspond to the selected Batch III formulation.

3.1. Organoleptic Evaluation

Table 2: Organoleptic evaluation of Shramahara Mahakashaya-based Ragi Saktu (n = 27)

Sensory Attribute	Like Extremely n (%)	Like Moderately n (%)	Neither Like nor Dislike n (%)	Dislike Moderately n (%)	Mean $\pm$ SD
Appearance & Colour	19 (70.37)	8 (29.63)	–	–	4.70 $\pm$ 0.47
Texture / Mouthfeel	17 (62.96)	10 (37.04)	–	–	4.63 $\pm$ 0.49
Taste / Flavour	21 (77.78)	6 (22.22)	–	–	4.78 $\pm$ 0.42
Aroma / Smell	25 (92.59)	1 (3.70)	1 (3.70)	–	4.89 $\pm$ 0.42
Crispness / Consistency	16 (59.26)	6 (22.22)	2 (7.41)	3 (11.11)	4.30 $\pm$ 1.03
Overall Acceptability	17 (62.96)	10 (37.04)	–	–	4.63 $\pm$ 0.49

Results: The developed Shramahara Mahakashaya-based Ragi Saktu demonstrated good overall sensory acceptability among the participants (n = 27). The highest mean score was observed for aroma/smell (4.89 $\pm$ 0.42), followed by taste/flavour (4.78 $\pm$ 0.42) and appearance & colour (4.70 $\pm$ 0.47). Texture/mouthfeel (4.63 $\pm$ 0.49) and overall acceptability (4.63 $\pm$ 0.49) also indicated favourable acceptance. The lowest mean score was observed for crispness/consistency (4.30 $\pm$ 1.03), which showed greater variability in responses. Overall, the findings indicated that the developed Saktu was well accepted by the participants

3.2. Physicochemical Characteristics

The Saktu preparation exhibited a pH of 4.34, indicating a mildly acidic character. The Loss on Drying was found to be 6.12%, indicating the moisture-related weight loss of the preparation under the specified analytical conditions.

Table 3: Physicochemical characteristics of Saktu

Parameter	Result
pH	4.34
Loss on Drying	6.12%

3.3. Nutritional Composition

Table 4: Nutritional composition of Shramahara Mahakashaya-based Ragi Saktu

S. No.	Nutritional Parameter	Result	Unit
1	Protein	6.72	g/100 g
2	Fat	6.32	g/100 g
3	Total Sugar	47.52	g/100 g
4	Energy Value*	399.64	kcal/100 g
5	Carbohydrate	78.97	g/100 g
6	Dietary Fibre	12.95	g/100 g
7	Calcium	1263.472	mg/kg
8	Folic Acid (Vitamin B9)	2.298	mg/kg
9	Trans Fatty Acid	BLQ (LOQ: 0.001 %)	%
10	Saturated Fatty Acid	2.10	%

*The energy value was 399.64 kcal/100 g. Using conventional Atwater factors, the value is calculated as follows:

$$\text{Energy} = (\text{Protein} \times 4) + (\text{Carbohydrate} \times 4) + (\text{Fat} \times 9)$$

$$\text{Protein} = 6.72 \text{ g/100 g}$$

Fat = 6.32 g/100 g

Carbohydrate = 78.97 g/100 g

Reported Energy = $(6.72 \times 4) + (78.97 \times 4) + (6.32 \times 9) = 399.64$ kcal/100 g

BLQ = Below Limit of Quantification; LOQ = Limit of Quantification.

Table 5: Amino Acid Profile

Amino Acid	Result (g/100 g)
Alanine	0.11
Arginine	BLQ (LOQ: 0.10 g/100 g)
Asparagine	0.45
Aspartic Acid	BLQ (LOQ: 0.10 g/100 g)
Cysteine	0.30
Glutamic Acid	BLQ (LOQ: 0.10 g/100 g)
Glutamine	BLQ (LOQ: 0.10 g/100 g)
Glycine	BLQ (LOQ: 0.10 g/100 g)
Histidine	BLQ (LOQ: 0.10 g/100 g)
Isoleucine	BLQ (LOQ: 0.10 g/100 g)
Leucine	0.91
Lysine	2.27
Methionine	BLQ (LOQ: 0.10 g/100 g)
Phenylalanine	0.54
Proline	0.74
Serine	0.30
Threonine	BLQ (LOQ: 0.10 g/100 g)
Tryptophan	0.77
Tyrosine	BLQ (LOQ: 0.10 g/100 g)
Valine	BLQ (LOQ: 0.10 g/100 g)
Total Amino Acids	6.38

BLQ = Below Limit of Quantification; LOQ = Limit of Quantification.

Overall, the findings indicate that the developed *Saktu* possessed appreciable amounts of protein, dietary fibre, calcium, folic acid, and amino acids, along with detectable energy and macronutrient content, supporting its potential nutritional value as a Ragi-based nutraceutical preparation.

3.4. Safety Evaluation

The heavy metal analysis showed that arsenic, cadmium and mercury were below the respective limits of quantification. Lead was detected at 0.403 mg/kg, which was below the applicable permissible limit of 2.5 mg/kg. [8]

All analysed aflatoxins, namely B₁, B₂, G₁ and G₂, were below their respective limits of quantification. Total aflatoxins were also below the reported LOQ.

Table 6: Heavy metal and aflatoxin profile of Saktu

Safety parameter	Result	Unit
Arsenic	BLQ (LOQ 0.10 mg/kg)	mg/kg
Cadmium	BLQ (LOQ 0.10 mg/kg)	mg/kg
Lead	0.403	mg/kg
Mercury	BLQ (LOQ 0.10 mg/kg)	mg/kg
Aflatoxin B ₁	BLQ (LOQ 0.5 µg/kg)	µg/kg
Aflatoxin B ₂	BLQ (LOQ 0.5 µg/kg)	µg/kg
Aflatoxin G ₁	BLQ (LOQ 0.5 µg/kg)	µg/kg
Aflatoxin G ₂	BLQ (LOQ 0.5 µg/kg)	µg/kg
Total aflatoxins	BLQ (LOQ 2.0 µg/kg)	µg/kg

BLQ = Below Limit of Quantification; LOQ = Limit of Quantification.

3.5. HPTLC Fingerprint Analysis

HPTLC fingerprinting of the selected ingredients/preparation showed characteristic chromatographic bands corresponding to the investigated marker compounds.

The *Badara/Ragi/Draksha* profile showed characteristic bands at Rf 0.93, 0.73 and 0.56, with the band at Rf 0.73 corresponding to the gallic acid reference marker.

The *Dadima* profile demonstrated a characteristic band at Rf 0.83,

corresponding to the punicalagin reference marker.

The *Parushaka* profile exhibited a prominent red-coloured band at Rf 0.80 under UV 366 nm, suggestive of terpenoid constituents.

The *Priyala* profile showed characteristic bands at Rf 0.66, 0.58 and 0.39 under UV 366 nm and a band at Rf 0.61 under white light. The band at Rf 0.66 corresponded to the quercetin reference marker.

Table 7: Summary of HPTLC fingerprint findings

Sample / marker	Characteristic Rf	Observation
<i>Badara/Ragi/Draksha</i> – Gallic acid	0.73	Corresponding band observed
<i>Dadima</i> – Punicalagin	0.83	Corresponding band observed
<i>Parushaka</i> – Terpenoids	0.80	Prominent red band under UV 366 nm
<i>Priyala</i> – Quercetin	0.66	Corresponding band observed

DISCUSSION

The present study was undertaken to develop and evaluate a *Shramahara Mahakashaya*-based Ragi Saktu as an Ayurvedic functional food. The formulation was conceptually based on the ten drugs described under *Shramahara Mahakashaya* by Acharya Charaka, namely *Draksha*, *Kharjura*, *Priyala*, *Badara*, *Dadima*, *Phalgu*, *Parushaka*, *Ikshu*, *Yava* and *Shashtika*. [2] Ragi (*Eleusine coracana*) was incorporated as the principal cereal base because of its recognized nutritional value, particularly its calcium and dietary-fibre content. [6,9]

The developed *Saktu* showed good sensory acceptability among the 27 participants. The highest mean score was observed for aroma/smell (4.89 ± 0.42), followed by taste/flavour (4.78 ± 0.42) and appearance/colour (4.70 ± 0.47). Overall acceptability was 4.63 ± 0.49 , indicating favourable consumer response. The comparatively lower score for crispness/consistency (4.30 ± 1.03) with a higher standard deviation suggests greater individual variation in perception of this attribute. Sensory evaluation is an important component of functional-food development because nutritional characteristics alone do not ensure consumer acceptance. [6,10]

The physicochemical assessment showed a pH of 4.34 and Loss on Drying of 6.12%. The mildly acidic pH may be related to the contribution of fruit-based ingredients, particularly *Dadima* and *Parushaka*. The LOD value indicates the moisture-related weight loss observed under the specified analytical conditions and provides a useful quality-control parameter for the dry *Saktu* preparation. However, these values alone cannot establish shelf stability, for which water activity, microbial quality and storage-stability studies would be required. Nutritionally, the formulation demonstrated appreciable energy and macronutrient content, with 399.64 kcal/100 g energy, 78.97 g/100 g carbohydrate, 6.72 g/100 g protein and 6.32 g/100 g fat. The carbohydrate-rich composition is consistent with the inclusion of Ragi, *Yava*, *Shashtika Shali*, dried fruits and *Khandsari* sugar. Such a composition provides substantial dietary energy and is relevant to the traditional objective of nourishment and support during physical exertion. Nevertheless, the present nutritional findings should not be interpreted as direct evidence of an anti-fatigue effect in humans. A notable finding was the dietary fibre content of 12.95 g/100 g. Finger millet is recognized as a fibre-rich cereal, and its

dietary fibre and polyphenolic constituents have been extensively investigated for their nutritional and potential functional significance. [10,11] The relatively high fibre content of the developed *Saktu* therefore represents an additional nutritional advantage of incorporating Ragi into the formulation.

The calcium concentration was 1263.472 mg/kg (approximately 126.35 mg/100 g). This finding is particularly relevant because finger millet is recognized for its comparatively high calcium content among cereals. [6,11] The calcium contribution may enhance the nutritional value of the formulation, although mineral bioavailability cannot be inferred from total calcium concentration alone.

The formulation contained 2.298 mg/kg folic acid, demonstrating a measurable folate contribution. Folate has important physiological roles in nucleotide synthesis and one-carbon metabolism; however, the present study establishes only the analytical presence of folic acid and does not demonstrate correction of folate deficiency or a clinical effect.

The amino acid analysis demonstrated detectable amounts of several amino acids, with lysine and leucine being prominent among the quantified amino acids. Finger millet has been reported to contain nutritionally relevant amino acids, including sulphur-containing amino acids, although its amino acid composition can vary with cultivar and processing. [6] The laboratory-reported total amino acid content of the developed *Saktu* was 6.38 g/100 g, with the remaining amino acids reported as below the limit of quantification (BLQ; LOQ 0.10 g/100 g).

The fatty acid analysis showed 2.10% saturated fatty acids, while trans fatty acids were below the limit of quantification (LOQ 0.001%). The absence of quantifiable trans fatty acids is a favourable nutritional characteristic. Since MUFA and PUFA values were not available in the present dataset, interpretation of the overall quality

of the lipid fraction should remain limited to the reported SFA and trans-fat findings.

The safety evaluation demonstrated that arsenic, cadmium and mercury were below the respective limits of quantification, whereas lead was detected at 0.403 mg/kg and remained below the permissible limit used for comparison in the analytical report. Assessment of heavy metals is particularly relevant for plant-derived foods because these contaminants may enter food materials through soil, water, agricultural practices and processing environments. [8] The findings therefore provide preliminary evidence of acceptable contaminant levels in the investigated batch.

Similarly, aflatoxins B₁, B₂, G₁ and G₂ and total aflatoxins were below their respective limits of quantification. This is an important quality finding for a cereal- and fruit-based product because aflatoxin contamination can occur during agricultural production, handling and storage under favourable conditions for fungal growth. FSSAI recognizes aflatoxins as important food contaminants and prescribes maximum limits for relevant food commodities. [12] The present results indicate that aflatoxins were not quantifiable in the tested batch under the analytical conditions employed.

HPTLC fingerprinting provided preliminary chromatographic characterization of selected formulation components. The observed bands corresponding to gallic acid, punicalagin and quercetin provide useful marker-based information for future quality standardization. The identification of a band corresponding to punicalagin is consistent with the established phytochemical profile of *Punica granatum*, in which hydrolysable tannins including punicalagin are important constituents. [13,14]

However, correspondence of *R_f* values should be regarded as preliminary chromatographic evidence rather than definitive structural identification unless supported by co-chromatography or an orthogonal analytical technique. Similarly, the band observed for *Parushaka* and interpreted as suggestive of terpenoids should be considered tentative.

Taken together, the findings demonstrate that the developed *Shramahara Mahakashaya*-based Ragi *Saktu* combines high sensory acceptability with appreciable nutritional density and satisfactory analytical safety. The formulation provides substantial dietary energy and carbohydrate together with protein, fibre, calcium and folate, while exhibiting non-quantifiable trans fatty acids and acceptable heavy-metal and aflatoxin findings. The results therefore support its potential as an Ayurvedic functional-food prototype.

Importantly, the present study was not designed as a clinical anti-fatigue trial. Although the classical *Shramahara* concept and the nutritional characteristics of the formulation provide a rational basis for its potential use as a supportive food during physical exertion, claims regarding reduction of fatigue or improvement in physical performance require validation through controlled human intervention studies. Further investigations should include stability studies, microbiological assessment, complete fatty acid characterization, validated quantitative marker analysis and clinical evaluation of fatigue-related outcomes.

CONCLUSION

The present study successfully developed a *Shramahara Mahakashaya*-based Ragi *Saktu* as an Ayurvedic functional-food prototype by integrating the classical *Shramahara Mahakashaya* concept with the nutritional attributes of Ragi. The developed formulation demonstrated good sensory acceptability, with overall acceptability of 4.63 ± 0.49 and the highest sensory response for aroma/smell (4.89 ± 0.42).

The formulation showed 399.64 kcal/100 g energy, 78.97 g/100 g carbohydrate, 6.72 g/100 g protein, 6.32 g/100 g fat and 12.95 g/100 g dietary fibre, along with appreciable calcium (1263.472 mg/kg) and folic acid (2.298 mg/kg). Trans fatty acids were below the limit of quantification, while the reported heavy-metal and aflatoxin results indicated satisfactory analytical safety of the

tested batch. HPTLC fingerprinting further provided preliminary evidence of characteristic marker bands corresponding to gallic acid, punicalagin and quercetin.

Overall, the findings indicate that the developed *Saktu* is a nutritionally dense, acceptable and analytically characterized Ayurvedic functional-food preparation with potential for further development as a convenient dietary product. However, the present study establishes nutritional and formulation potential rather than clinical anti-fatigue efficacy. Controlled human studies are warranted to determine its actual effect on fatigue, physical performance and related nutritional outcomes.

Declaration by Authors

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