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AN INTEGRATIVE REVIEW OF FERMENTED MILLET *AMBALI* POWDER: SYNERGIES BETWEEN AYURVEDIC PHARMACOLOGY AND CONTEMPORARY NUTRITIONAL SCIENCE

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ABSTRACT: *Ambali* is a traditional lactic acid-fermented porridge prepared from finger millet (*Eleusine coracana*), representing a significant convergence point between functional food science and culinary traditions. This narrative review examines the preparation, proposed health benefits, and mechanistic basis of dehydrated *Ambali* powder by integrating Ayurvedic *Dravyaguna* (pharmacological) principles with contemporary food biochemistry. Classical Ayurvedic literature was critically reviewed alongside recent *in-vitro*, *in-vivo*, and limited clinical research to interpret traditional claims through scientific evidence. From an Ayurvedic perspective, fermented *Ambali* exhibits *Amla Rasa* (sour taste), *Laghu* (light) and *Sukhoshna* (comfortably warm) *Guna* (qualities), *and Pitta-Kaphahara* (pacifying *Pitta* and *Kapha doshas*) action, attributed to its capacity to enhance Agni (digestive/metabolic fire) and prevent Ama (undigested metabolic toxin) formation. Contemporary research demonstrates that lactic acid fermentation enhances nutrient bioavailability, reduces antinutritional factors, generates bioactive compounds, and provides probiotic microorganisms. Biochemical mechanisms underlying improved digestibility and metabolic support include microbial enzymatic hydrolysis, phytate degradation, and organic acid production. The convergence of Ayurvedic digestive concepts with modern understanding of gut microbiome modulation underscores Ambali's potential as a functional food. However, further clinical validation, standardized fermentation protocols, and metabolomic studies are required to facilitate its translation into evidence-based nutritional practice.

INTRODUCTION: Fermented millet *Ambali* represents a traditional lactic acid-fermented porridge that occupies a significant position at the intersection of culinary heritage and functional food science [1].

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This review examines the preparation, proposed health benefits, and mechanistic basis of dehydrated *Ambali* powder through an integrative analysis of Ayurvedic *Dravyaguna* concepts and food biochemistry.

By critically interpreting classical Ayurvedic texts alongside contemporary *in-vitro*, *in-vivo*, and limited clinical research, this narrative synthesis aims to contextualize traditional claims within modern scientific frameworks. Fermentation extends beyond preservation to constitute a

dynamic biotransformation process that functions as exogenous pre-digestion. In food science, fermentation is defined as the controlled transformation of food substrates by microbial enzymes, producing metabolites that substantially modify nutritional composition, bioactivity, and sensory properties [2]. Lactic acid fermentation, in particular, has been documented to introduce probiotic microorganisms, enhance mineral bioavailability, and generate health-promoting compounds including bioactive peptides and short-chain fatty acids [3]. These effects are associated with improved gastrointestinal function, metabolic regulation, and immune modulation, aligning with global trends toward functional and personalized nutrition [4].

Concurrently, Ayurveda, the traditional Indian medical system, offers a comprehensive, personalized approach to dietetics as both preventive and therapeutic intervention. Health (*Swasthya*) is understood as the dynamic equilibrium of three primary bioenergies or doshas: *Vata* (kinetic principle), *Pitta* (transformative principle), and *Kapha* (cohesive principle). Among the factors influencing this balance, *Ahara* (food) is considered paramount [5]. Foods are systematically classified according to Rasa (taste), *Guna* (qualities), *Virya* (potency), *Vipaka* (post-digestive effect), and *Prabhava* (unique effect), which collectively modulate doshic balance and Agni—the metabolic fire governing all assimilation and transformation processes [6]. Fermented foods occupy a distinctive position in Ayurvedic dietetics due to their *Deepana* (appetite-enhancing) and *Pachana* (digestive) properties. Fermentation typically renders foods *Laghu* (light), thereby supporting compromised Agni and counteracting Ama formation, a fundamental pathological mechanism in Ayurveda [7].

Despite the considerable cultural and therapeutic potential of fermented millet *Ambali*, the literature lacks comprehensive scholarly synthesis that critically integrates Ayurvedic pharmacodynamics with rigorous evaluation of contemporary scientific evidence. Existing studies predominantly examine isolated parameters such as proximate composition, microbiological profiles, or singular health effects, without constructing a coherent narrative bridging these knowledge systems [8].

The present review addresses this gap through purposeful and critical analysis of fermented finger millet *Ambali* powder, comparing its traditional Ayurvedic characterization with modern biochemical, nutritional, and physiological data. This integrative approach illuminates areas of concordance and discordance, identifies plausible mechanistic connections underlying traditional claims, and delineates knowledge gaps to inform future research, thereby situating this traditional functional food within an evidence-based context.

MATERIALS AND METHODS:

Review Design: This narrative review synthesizes information on fermented millet *Ambali* from classical Ayurvedic literature and contemporary scientific studies. Given the heterogeneous nature of available evidence encompassing ancient texts, experimental studies, and clinical research, a narrative approach was adopted to enable integrative interpretation across disciplinary boundaries.

Search Strategy: Electronic databases including PubMed, Scopus, Web of Science, AYUSH Research Portal, and Google Scholar were systematically searched from January 2000 through March 2025. The search strategy employed combinations of the following keywords: "finger millet" OR "*Eleusine coracana*" OR "ragi" AND "fermentation" OR "lactic acid bacteria" AND "*Ambali*" OR "koozh" AND "Ayurveda" AND "traditional fermented foods." Reference lists of retrieved articles were manually screened for additional relevant publications. For Ayurvedic classical literature, digital repositories containing Sanskrit texts including the *Charaka Samhita*, *Sushruta Samhita*, *Ashtanga Hridaya*, and *Bhavaprakasha Nighantu* were accessed. Relevant sections were identified using Sanskrit terms for grains (*dhanya*), fermented preparations (*dadhikarma*), and taste/quality classifications (*rasa*, *guna*).

Inclusion and Exclusion Criteria:

Studies were included if they met the following criteria:

- Investigated fermented millet preparations, specifically those analogous to *Ambali* or *koozh* (traditional Indian fermented millet porridge);

- Reported outcomes related to nutritional composition, microbiological characteristics, bioactive compound generation, or health effects (glycemic response, gastrointestinal function, antioxidant activity, or metabolic parameters);
- Comprised experimental studies (*in-vitro*, *in-vivo*), clinical trials, or systematic reviews;
- Were published in English or had available English translations.

Studies were Excluded if they:

- Examined non-fermented millet preparations without fermentation components;
- Investigated fermented products from non-millet substrates without relevance to *Ambali*;
- Comprised opinion pieces, conference abstracts without full data, or non-peer-reviewed sources;
- Lacked sufficient methodological detail for quality assessment.

Data Extraction and Synthesis: From contemporary scientific literature, data were extracted on study characteristics (author, year, design), millet type and fermentation parameters, outcome measures, and key findings. From classical Ayurvedic texts, descriptions of millet properties (*Rasa, Guna, Virya, Vipaka, Dosha karma*), fermentation effects (*Sanskara*), and therapeutic indications were extracted and recorded.

Due to the methodological heterogeneity of included sources, quantitative meta-analysis was not feasible. Synthesis was conducted narratively, organizing findings according to Ayurvedic pharmacological parameters and modern scientific processes, followed by integrative interpretation examining points of convergence and divergence between the two knowledge systems.

Quality Considerations: For contemporary studies, methodological quality was appraised considering study design, sample size, appropriate controls, and outcome measure validity. For classical texts, authenticity and interpretative consensus among traditional commentators were considered. Given the narrative review design, formal quality scoring was not applied, but methodological limitations are discussed in interpreting evidence strength.

RESULTS:

Ayurvedic Pharmacological Profile:

Finger Millet (*Ragi, Eleusine coracana*) in Classical Texts: Classical Ayurvedic texts classify millets, including finger millet (*Ragi*), within the category of *Trinadhanya* (inferior grains). According to the *Bhavaprakasha Nighantu*, finger millet possesses predominantly *Kashaya* (astringent) taste with subordinate *Madhura* (sweet) *Rasa* [9]. Its inherent qualities (*Guna*) are described as *Ruksha* (dry) and *Laghu* (light). The Virya (potency) is *Sheeta* (cooling), and the Vipaka (post-digestive effect) is *Katu* (pungent) [10]. This specific combination of properties renders finger millet effective in pacifying *Kapha* and *Pitta doshas*. However, classical authorities caution that excessive consumption or use without appropriate processing may aggravate *Vata dosha* due to its drying and light qualities. Although finger millet is considered strengthening (*Balya*), it requires robust Agni for optimal digestion and assimilation [11].

Biotransformation through *Dadhikarma* (Fermentation Process): Fermentation constitutes a significant *Sanskara* (processing technique) that fundamentally transforms the intrinsic properties (*Prakriti*) of the substrate, generating novel emergent properties (*Vikriti)* [12]. According to Ayurvedic principles, this transformation occurs through several mechanisms:

***Rasa Parinama* (Taste Transformation):** The predominant *Rasa* shifts from *Kashaya-Madhura* to distinctly *Amla* (sour). *Amla Rasa*, when consumed in moderation, is recognized for its *Deepan*a (appetizing) and *Pachana* (digestive) actions, stimulating salivary secretion, enhancing gastric acid production, and initiating digestive processes [13].

***Guna Parinama* (Quality Transformation):** While base millet is inherently *Laghu* (light), fermentation substantially enhances this property. Complex carbohydrates and proteins undergo partial microbial hydrolysis, effectively "pre-digesting" the substrate and producing a *Sukhoshna*

(comfortably warm) state that renders the food readily assimilable by digestive forces (*Jatharagni*), thereby reducing metabolic burden [14].

The cooling potency (*Sheeta Virya*) of the base millet is partially retained, contributing to *Pittahara* (Pitta-pacifying) action. Simultaneously, fermentation introduces a subtle Ushna (heating) effect during digestion without causing excessive thermal increase. The *Vipaka* (post-digestive effect) likely maintains the light, catabolic, and channel-cleansing (*Srotoshodhana*) influence.

The finished product demonstrates dual doshic action: *Pittahara* through its cooling properties and *Kaphahara* (Kapha-pacifying) through its dry, light qualities and catabolic post-digestive effect. Its primary therapeutic action manifests in the *Annavaha Srotas* (gastrointestinal channel), where it functions as *Deepaniya* (appetizer) and *Pachaniya* (digestive), stimulating *Jatharagni* while inhibiting *Ama* formation [15]. Classical wisdom recommends that individuals with *Vata* predominance (*Vataja Prakriti*) or *Vata* disorders (*Vataja Vikriti*) exercise caution due to the preparation's *Ruksha* (dry) nature, potentially counterbalancing this by consuming *Ambali* with healthy fats or in moderation.

TABLE 1: AYURVEDIC PHARMACODYNAMIC PROFILE OF FINGER MILLET BEFORE AND AFTER FERMENTATION

Pharmacological Parameter	Base Finger Millet	Fermented Millet *Ambali*	Rationale for Transformation
Predominant *Rasa*	*Kashaya* (astringent), *Mad hura* (sweet) [9]	*Amla* (sour) [13]	Microbial production of lactic acid and other organic acids during fermentation [9, 13, 22]
Primary *Guna*	*Ruksha* (dry), *Laghu* (light) [10]	*Laghu* (light), *Sukhoshna* (comfortably warm) [14]	Enzymatic pre-hydrolysis of starches and proteins by fermentative microbiota reduces molecular complexity [10, 14, 24, 25]
Virya (Potency)	*Sheeta* (cooling) [10]	*Sheeta* (cooling) with subtle *Ushna* (warming) component [13]	*Amla Rasa* inherently carries mild heating energy during digestion while base cooling property partially retained [10, 13]
Vipaka (Post-digestive effect)	*Katu* (pungent) [10]	*Katu* (pungent)	Largely retained; contributes to metabolic lightness and channel cleansing [10]
Dosha Action	*Kaphahara*, *Pittahara*; may aggravate *Vata* in excess [10, 11]	*Pittahara*, *Kaphahara*; use cautiously in *Vata* imbalance [15]	Cooling and light properties pacify *Pitta* and *Kapha*; dryness may potentially imbalance *Vata* [10, 11, 15]
Effect on *Agni*	Requires strong *Agni* for digestion [11]	*Deepana* (appetizer), *Pac hana* (digestive) [7, 13]	Sour taste and pre-digested nature stimulate digestive secretions and reduce metabolic load [7, 11, 13, 14]

Scientific Evidence:

Microbial Ecology of *Ambali* Fermentation: *Ambali* fermentation is a natural process primarily driven by a symbiotic community of lactic acid bacteria (LAB), with secondary involvement of yeasts. Culture-dependent and independent studies have identified predominantly LAB species including *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Lactobacillus casei*, *Pediococcus pentosaceus*, and *Weissella confusa* in traditional fermented millet preparations analogous to *Ambali* [16, 17]. These microorganisms metabolize available carbohydrates through glycolysis and the pentose phosphate pathway, producing lactic acid (homofermentation) or a mixture of lactic acid, acetic acid, ethanol, and carbon dioxide (heterofermentation). This metabolic activity acidifies the substrate (typically pH decreases to 3.8-4.5 in finished *Ambali*), imparts characteristic sour taste, and inhibits pathogenic microbiota through low pH and bacteriocin production [18, 19]. This biochemical acidification constitutes the material correlate of *Amla Rasa* manifestation.

Nutritional and Functional Modifications During Fermentation: Fermentation induces cascading biochemical modifications that substantiate Ayurvedic concepts of enhanced digestibility (*Laghu*, *Sukhoshna*) and bioavailability.

Carbohydrate Metabolism: LAB produce various extracellular enzymes including amylases, pullulanase, and glucoamylase that hydrolyze complex starches into dextrins, maltose, and glucose [20].

These simpler carbohydrates are further metabolized to organic acids. Reduced starch complexity and organic acid generation contribute to lower glycemic index of fermented millet products, aligning with the concept of *Laghu* (light) and pre-digested characteristics [21].

Protein Modification and Bioactive Peptide Generation: LAB proteolytic systems comprising cell-wall-bound proteinases and intracellular peptidases degrade millet proteins into smaller peptides and free amino acids, substantially enhancing protein digestibility and nutritional quality [22]. Importantly, controlled proteolysis releases encrypted bioactive peptides exhibiting multifunctional properties including antioxidant, angiotensin-converting enzyme (ACE) inhibitory, dipeptidyl peptidase-IV (DPP-IV) inhibitory, and anti-inflammatory activities. These peptides provide molecular foundations for specific health benefits extending beyond fundamental nutrition [23, 24].

Improved Mineral Bioaccessibility: Phytic acid (myo-inositol hexaphosphate), a potent chelator of divalent cations (iron, zinc, calcium), is significantly reduced during fermentation through microbial phytase enzymes expressed by various LAB strains [25].

This enzymatic degradation substantially increases the soluble, absorbable fraction of these minerals under simulated gastrointestinal conditions, providing mechanistic support for enhanced mineral absorption and alignment with Ayurvedic concepts of proper *Dhatu* (tissue) nourishment [26].

Vitamin Biosynthesis: Specific LAB strains demonstrate capacity for de novo B-vitamin synthesis. *Lactobacillus plantarum* and certain *Lactobacillus fermentum* strains can produce folate (vitamin B9), riboflavin (vitamin B2), and cobalamin (vitamin B12) during food fermentation, thereby biofortifying the resulting food matrix particularly relevant for plant-based substrates [27].

Polyphenol Mobilization and Antioxidant Enhancement: Fermentation facilitates hydrolysis of bound phenolic compounds, including phenolic acids esterified to cell wall components, through microbial esterase activity, increasing the proportion of free, bioaccessible polyphenols [28]. This release, combined with antioxidant peptide generation, enhances cumulative *in-vitro* and *ex-vivo* antioxidant properties of fermented millet, potentially contributing to reduced oxidative stress *in-vivo* a mechanism potentially corresponding to *Ama-Pachana* (metabolic toxin digestion) [29].

TABLE 2: SCIENTIFIC CORRELATES OF AYURVEDIC PROPERTIES IN FERMENTED FINGER MILLET

Biochemical Process	Measurable Change	Physiological Implication	Correlated Ayurvedic Principle
Lactic Acid Fermentation	pH reduction (3.8-4.5); organic acid production (lactic, acetic) [18, 19]	Preservation, flavor development, pathogen inhibition, modulation of gastric environment	Manifestation of *Amla Rasa*; initiation of digestive stimulation [13, 18, 19, 34]
Starch Hydrolysis	Increased simple sugars and organic acids; reduced starch complexity [20, 21]	Lowered glycemic index and glycemic load; eased digestion	*Laghu Guna* and pre-digestion (*Sukhoshna*); supports Kapha pacification [14, 20, 21, 35]
Proteolysis and Bioactive Peptide Release	Increased peptides and free amino acids; generation of ACE-inhibitory, antioxidant, DPP-IV inhibitory peptides [22, 23, 24]	Improved protein digestibility; targeted cardiometabolic effects (antihypertensive, hypoglycemic potential)	Enhanced digestibility; potential *Prabhava* (specific therapeutic action) [22, 23, 24, 40]
Phytate Degradation	Significant reduction in phytic acid content [25]	Enhanced *in-vitro* and *in-vivo* bioaccessibility of iron, zinc, calcium [26]	Improved *Ahara Rasa* (nutrient essence) assimilation; supports *Dhatu Poshana* (tissue nourishment) [25, 26]
Polyphenol Mobilization	Increased free phenolic content; elevated *in-vitro* antioxidant activity (DPPH, FRAP, ORAC) [28, 29]	Enhanced systemic antioxidant defense; potential anti-inflammatory effects	*Ama-Pachana* (digestion/neutralization of metabolic toxins) [28, 29, 38]
Probiotic Microbiota	Viable *Lactobacillus* spp., *Pediococcus* spp. demonstrated in traditional fermented millet [16, 17]	Gut microbiome modulation, improved barrier function, immunomodulation, competitive pathogen exclusion	Strengthening of *Agni* at gastrointestinal level; correction of *Koshtha* (bowel function) [16, 17, 34, 36]

Documented Health Outcomes: Emerging research, primarily utilizing analogous fermented millet models or extracts, provides empirical support for traditional health claims associated with *Ambali*.

Glycemic Regulation: Studies investigating fermented millet products have demonstrated lower glycemic index compared to unfermented counterparts or refined grains [21, 30].

This effect is attributed to organic acid-mediated delay in gastric emptying, inhibition of digestive enzymes, and resistant starch formation. These findings align with traditional use of millet preparations in conditions characterized by impaired glucose metabolism, insulin resistance, and metabolic syndrome contemporary correlates of *Pitta-Kapha* disorders.

Gastrointestinal Benefits: Lactic acid bacteria isolated from traditional fermented millet preparations exhibit probiotic characteristics, including survival during simulated gastrointestinal transit, temporary gut colonization potential, enhancement of intestinal barrier integrity through tight junction protein upregulation, modulation of commensal microbial composition (e.g., increasing *Bifidobacterium* spp.), and antagonism of enteropathogens through competitive adhesion and bacteriocin production [31, 32].

These mechanisms provide scientific rationale for *Deepana-Pachana* actions and Agni strengthening at the gastrointestinal level through establishment of healthy gut ecology.

Cardiometabolic Effects: Animal model studies utilizing fermented millet extracts have demonstrated significant reductions in serum triglycerides, total cholesterol, and low-density lipoprotein cholesterol (LDL-C), with occasional increases in high-density lipoprotein cholesterol (HDL-C) [33].

These effects are attributed to bioactive peptides, soluble dietary fiber (including beta-glucan present in millets), and microbial metabolites (e.g., short-chain fatty acids such as propionate). Such findings corroborate *Kaphahara* and *Medohara* (fat-metabolizing) properties relevant to conditions of excess *Kapha*, including obesity and dyslipidemia.

Antioxidant and Anti-inflammatory Potential: Enhanced antioxidant activity of biotransformed polyphenols and peptides observed in vitro and ex vivo correlates with reduced oxidative stress markers (e.g., malondialdehyde) and modulation of inflammatory cytokine expression (e.g., TNF-α, IL-6) in animal models [29, 34]. These mechanisms parallel systemic manifestations of Ama accumulation and Dhatvagni (tissue-level metabolic) impairment, which Ayurveda identifies as antecedents to chronic inflammatory and degenerative conditions.

DISCUSSION: The foregoing analysis demonstrates substantial concordance between Ayurvedic conceptualizations of fermented finger millet *Ambali* and findings from contemporary food science, microbiology, and nutritional biochemistry. This synergy extends beyond superficial parallels to reveal coherent frameworks wherein empirically-derived traditional knowledge finds mechanistic explanation within modern biological paradigms.

Centrality of Digestive Function:

Agni and Gastrointestinal Health: The most significant epistemological convergence centers on the concept of Agni. In Ayurveda, Agni encompasses not merely gastric digestion but the entirety of metabolic and transformative processes throughout the organism, with *Jatharagni* (gastrointestinal digestive capacity) representing its most critical expression [6]. *Ama* a poorly digested, sticky, toxic residue results from diminished or irregular Agni (*Mandagni, Vishamagni*). Fermented *Ambali* is traditionally classified as *Deepaniya* (appetizer) and *Pachaniya* (digestive).

Contemporary research demonstrates that LAB consortia and their metabolites in fermented millet promote gastrointestinal health through multiple mechanisms: acidification of luminal environment (activating endogenous pepsin), provision of microbial digestive enzymes (amylases, proteases), bacteriocin production, competitive exclusion of pathogens, gut-brain axis signaling, and modulation of innate and adaptive immune responses [31, 32, 35]. These mechanisms collectively provide scientific validation for enhanced digestive efficiency, nutrient absorption, and gut barrier function constituting experimental support for *Agni*

strengthening and *Ama* prevention at the levels of microbial ecology and mucosal physiology. The probiotic action of *Ambali* directly relates to regulation of *Koshtha* (bowel function), a primary clinical manifestation of Agni status.

Predictive Capacity of Ayurvedic Pharmacology: The Ayurvedic pharmacological system demonstrates considerable predictive power regarding food effects. The transformation to *Amla* Rasa during fermentation is quantitatively supported by documented increases in titratable acidity and pH reduction [18, 19]. The development of *Laghu Guna* and acquisition of *Sukhoshna* state correlate directly with macronutrient molecular simplification through microbial enzymatic pre-digestion, reducing the thermal effect of food and metabolic load [20, 21]. The cooling potency (*Sheeta Virya*) attributed to *Ambali*, modulated by subtle warming influence of *Amla* Rasa during digestion, finds physiological correlate in the food's anti-inflammatory and antioxidant properties [29, 34], which would counter excessive *Pitta* (associated with heat, inflammation, and acidity). This represents a pre-scientific holistic algorithm for predicting food physiological behavior that can be progressively deconstructed into individual biochemical pathways and molecular interactions through reductionist scientific approaches.

Dosha-Specific Actions and Physiological Correlates: The classification of *Ambali* as *Pittahara* and *Kaphahara* finds physiological validation through multiple mechanisms. *Pittahara* (*Pitta*-pacifying) effect is supported by the preparation's cooling property, antioxidant capacity, and ability to modulate gastrointestinal inflammation actions countering classical *Pitta* disorders including gastritis, hyperacidity, and inflammatory skin conditions [34]. *Kaphahara* (*Kapha*-pacifying) action is evidenced by the product's light digestibility, low glycemic and insulinemic responses [21, 30], and hypolipidemic effects [33] properties directly opposing the heavy (Guru), slow (*Mand*a), sticky (*Picchila*), and accumulative (Sandra) characteristics of *Kapha* imbalance. In contemporary terms, these properties translate to relevance in obesity, metabolic syndrome, diabetes mellitus, and congestive disorders [36]. The traditional caution regarding potential *Vata* aggravation reflects the preparation's inherent *Ruksha* (dry) quality, demonstrating the individualized, constitutional approach fundamental to Ayurvedic therapeutics.

Prabhava and Bioactive Peptide Generation: The Ayurvedic principle of *Prabhava*, denoting unique or extraordinary action not predictable from known *Rasa, Guna, Virya*, or *Vipaka* finds a potential modern correlate in the generation of specific bioactive peptides with potent physiological activities. Peptides exhibiting ACE-inhibitory, DPP-IV inhibitory, or antioxidant activities [23, 24] represent emergent properties arising specifically through fermentation, *Sanskara* (processing). These encrypted sequences possess therapeutic qualities extending beyond the nutritive value of unfermented millet, demonstrating how traditional processing methods can liberate latent, potent bioactivities within food matrices consistent with the concept that *Sanskara* fundamentally transforms a substance's potential (*Shakti*).

Knowledge Gaps and Future Research Directions: Despite the promising convergence documented in this review, significant knowledge gaps remain. Standardized characterization of *Ambali* fermentation parameters (substrate ratios, fermentation time and temperature, starter culture practices) is lacking, limiting reproducibility. The viability of probiotic microorganisms in dehydrated *Ambali* powder preparations requires systematic investigation, as drying and storage conditions critically influence microbial survival. Most health effect studies have utilized analogous fermented millet models rather than *Ambali* specifically, and human clinical trials remain scarce. Metabolomic profiling to comprehensively characterize bioactive compounds generated during fermentation would strengthen mechanistic understanding. Furthermore, rigorous clinical studies examining dose-response relationships, duration of effects, and specific therapeutic indications in defined populations are needed to translate traditional knowledge into evidence-based nutritional practice.

CONCLUSION: This integrative review establishes fermented finger millet *Ambali* powder as a traditional functional food where Ayurvedic principles highlighting its sour taste, light quality, *Pitta-Kaphahara* action, and digestive fire enhancement align with modern evidence of

fermentation-driven nutrient bioavailability, antinutrient reduction, bioactive peptide generation, and probiotic support. While this convergence validates *Ambali's* therapeutic potential, critical research gaps remain in protocol standardization, probiotic viability in dehydrated forms, metabolomic profiling, and clinical trials, whose pursuit would not only validate this traditional food but also uncover novel strategies for metabolic and gastrointestinal health through an integrative, personalized nutrition paradigm.

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