

Research Article

A POLY HERBAL AYURVEDIC NUTRACEUTICAL FORMULATION FOR PHYSICAL PERFORMANCE, FATIGUE REDUCTION, AND IMMUNE ENHANCEMENT

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ABSTRACT

Ayurveda, the ancient Indian system of medicine, has for millennia employed plant-derived formulations to promote health, vitality, and longevity. With growing global interest in preventive healthcare and natural wellness solutions, Ayurvedic herbs are increasingly being validated through the lens of modern pharmacological science. The convergence of traditional knowledge and contemporary research has given rise to a new product category — nutraceuticals — defined by DeFelice (1989) as food-derived products that provide extra-nutritional, health-promoting or disease-preventing benefits beyond their basic nutritional value. India's nutraceutical industry has witnessed remarkable growth in the post-COVID era, driven by heightened consumer awareness of preventive healthcare and renewed interest in herbal remedies. According to Grand View Research (2024), the Indian nutraceuticals market was valued at USD 32.14 billion in 2024 and is projected to reach USD 75.81 billion by 2033, at a compound annual growth rate (CAGR) of 10.0%. Within this landscape, Ayurvedic health drinks represent one of the fastest-growing segments, with the India Ayurvedic health drinks market valued at USD 1.1 billion in 2024 and projected to reach USD 2.7 billion by 2033 at an 11% CAGR (IMARC Group, 2024). This literature review examines the scientific basis of the Blend — a polyherbal instant drink formulation comprising five botanicals: *Withania somnifera* (Ashwagandha), *Tinospora cordifolia* (Giloy), *Phyllanthus emblica* (Amla), *Ocimum sanctum* (Tulsi), and *Zingiber officinale* (Ginger). The formulation is designed to address physical fatigue, enhance immunity, and improve overall functional capacity. The review establishes the pharmacological rationale for each individual ingredient, examines the scientific basis for their synergistic combination, explores the regulatory framework for nutraceutical classification in India, assesses market relevance, and identifies research gaps that justify this novel product.

INTRODUCTION

Withania somnifera (L.) Dunal, commonly known as Ashwagandha or Indian Winter Cherry, belongs to the family Solanaceae. The root is the primary part used therapeutically. It has been classified as a Rasayana (rejuvenating herb) in classical Ayurvedic texts including the Charaka Samhita and Sushruta Samhita. The primary bioactive constituents of *W. somnifera* are withanolides — a class of naturally occurring steroidal lactones, particularly withanolide A, withaferin A, and withanoside IV. Additional constituents include alkaloids (withanine, somnine), saponins, sitoindosides, and iron. Withanolides are responsible for the majority of pharmacological effects including adaptogenic, anti-inflammatory, antioxidant, and neuroprotective activities.^[1]

Pharmacological Evidence

Ashwagandha has perhaps the most extensive clinical evidence base of all the herbs in this formulation. A landmark PRISMA-based systematic review and Bayesian meta-analysis by Pérez-Gómez et al. (2021), published in the Journal of Human Kinetics and indexed on PubMed Central, evaluated 13 clinical trials assessing the effect of *W. somnifera* on physical performance. The analysis encompassed variables including muscle strength, VO₂max, muscle fatigue, tiredness, and physical recovery. Results demonstrated statistically significant improvements across multiple domains of physical performance in healthy adults receiving ashwagandha supplementation.

A recent double-blind, randomized, placebo-controlled study (Wiley Online Library, 2025) examined the efficacy and safety of a low-dose ashwagandha extract (30 mg/day) standardized to withanolides over eight weeks. The primary endpoint — VO₂max assessed via the Modified Bruce Protocol Treadmill Test — showed significant improvement compared to placebo, alongside reductions in exercise-induced fatigue scores (VAS) and lactic acid accumulation. Secondary biomarkers including creatine phosphokinase (CPK) also reflected reduced muscle damage.

A comprehensive narrative review by Wankhede et al. (2025), published in PMC, synthesized available evidence on the effects of ashwagandha supplementation on strength, endurance, power, recovery, muscle mass, anxiety, metabolic health, and aging. The review identified withanolides' ability to modulate the hypothalamic-pituitary-adrenal (HPA) axis as a key mechanism underlying observed anti-stress and performance-enhancing outcomes. Additionally, a systematic review by Luszczak and Kocki (2025), published in the Annals of Agricultural and Environmental Medicine, confirmed adaptogenic benefits of *W. somnifera* across 19 RCTs, with particular emphasis on psychometric and physiological stress outcomes.

Safety and Dosage

Ashwagandha root extract is well-tolerated in clinical doses of 300–600 mg/day of standardized extract. Adverse effects are uncommon and typically mild (gastrointestinal discomfort). It should be used with caution in pregnancy, autoimmune disorders, and in patients on thyroid or immunosuppressant medications.^[2]

Tinospora cordifolia (Giloy)-*Tinospora cordifolia* (Willd.) Miers, commonly known as Giloy, Guduchi, or Amrita ('nectar of immortality'), belongs to the family Menispermaceae. The stem is the most commonly used part. In Ayurvedic classification, Giloy is considered a Tridoshahara (balancing all three doshas) and is revered as one of the most potent immunomodulatory herbs in the Indian pharmacopoeia.

Phytochemistry

T. cordifolia is rich in a diverse array of bioactive compounds including alkaloids (berberine, palmatine, tinosporine, isocolumbin), diterpenoid lactones (furanolactone, clerodane derivatives), polysaccharides, glycosides (tinocordiside, cordioside), phenolics, and steroids. These phytochemical classes collectively account for its broad-spectrum pharmacological activities.

Pharmacological Evidence-Immunomodulatory activity is the most extensively documented property of *T. cordifolia*. A 2024 review in *Heliyon* (Cell Press) focused on giloy leaves and confirmed potent immunomodulatory effects mediated through multiple pathways, including NF- κ B signalling suppression, interleukin modulation, phagocytosis stimulation, and regulation of apoptosis in immune cells. The authors highlighted giloy's potential for incorporation into functional food products and beverages (PMC11699423, 2024).

A comprehensive pharmacological review in *Heliyon* (2024) surveyed over two decades of scientific investigation into *T. cordifolia*. The evidence documented anti-inflammatory activity via reduction of pro-inflammatory cytokines including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α), as demonstrated in rheumatoid arthritis models. The review further confirmed anti-diabetic, antioxidant, anti-microbial, anti-allergic, and hepatoprotective activities arising from its diverse phytochemical constituents including alkaloids, phenolics, diterpenoids, glycosides, and steroids (PMC10882059, 2024).

A 2024 review in PubMed (PMID 40353407) explored giloy's nutraceutical and medicinal potential specifically for stress and cancer management. It confirmed that *T. cordifolia*'s antioxidant phytochemicals counter free radicals, reduce cellular oxidative damage, and demonstrate significant hepatoprotective effects. Preclinical evidence showed that giloy enhances endogenous antioxidant defenses and can improve quality of life as adjunct therapy.^[3]

Safety and Dosage

Giloy is considered safe at standard therapeutic doses (300–500 mg of stem powder or extract daily). There have been isolated case reports of hepatotoxicity with commercial giloy preparations; however, these are attributed to adulteration or contamination rather than the pure plant material. Pure, standardized giloy stem extract has an established safety profile.

Phyllanthus emblica (Amla)

Phyllanthus emblica L. (syn. *Emblica officinalis*), commonly known as Amla or Indian Gooseberry, belongs to the family Phyllanthaceae. The fruit is the primary part used therapeutically. Amla is one of the three constituents of Triphala — perhaps the most well-known Ayurvedic formulation — and is classified as a powerful Rasayana in classical texts.^[4]

Phytochemistry

Amla fruit is extraordinarily rich in polyphenols including tannins (emblicanin A and B, punigluconin), gallotannins, ellagic acid, gallic acid, and quercetin. Notably, amla contains exceptionally high levels of Vitamin C (ascorbic acid), with concentrations approximately 20 times greater than oranges. However, the Vitamin C in amla is uniquely stabilized by tannins and is retained even during drying, distinguishing it from other vitamin C sources.

Pharmacological Evidence

A rigorous review in *Antioxidants* (MDPI, 2022) — indexed on PubMed (PMID 35624683) and PMC (PMC9137578) — comprehensively assessed amla's nutraceutical significance. The review confirmed that the rich polyphenol and Vitamin C composition imparts important antioxidant activity, with demonstrated improvements in the body's endogenous antioxidant defense system. Additional evidence supported anti-hyperlipidemia, antidiabetic, anticancer, anti-inflammatory, digestive tract protective, and neurological protective activities.

A 2023 comprehensive review in *Frontiers in Pharmacology* (PMC10637531) examined amla's broad phytochemical profile and multiple pharmacological mechanisms. Of direct relevance to the formulation, the review documented amla's significant hepatoprotective effects — it substantially reduces body weight, peritoneal fat, and improves antioxidant enzyme activities in metabolic stress models. Its gallic acid content is proven in vivo to improve dyslipidemia and oxidative stress induced by high-fat diets.

Of particular note for physical performance applications: amla supports collagen biosynthesis through its high vitamin C content, contributing to structural integrity of muscles, tendons, and connective tissue. Additionally, its antioxidant profile directly combats exercise-induced oxidative stress — a primary driver of fatigue in physically active individuals.^[5]

Safety and Dosage

Amla is among the safest herbs in the Ayurvedic pharmacopoeia. It is classified as a food ingredient and is consumed widely as fruit, juice, and powder across India. Therapeutic doses of 500–1000 mg of amla powder daily are well-tolerated with no significant adverse effects documented.

Ocimum sanctum / tenuiflorum (Tulsi)

Ocimum sanctum L. (synonym: *O. tenuiflorum*), commonly known as Tulsi or Holy Basil, belongs to the family Lamiaceae. The leaves and essential oil are the primary parts used medicinally. Tulsi holds both cultural and medicinal significance in India, described in ancient Sanskrit texts as 'The Queen of Herbs' and 'The Incomparable One.' It is one of the most studied plants in Ayurvedic medicine for adaptogenic properties.

Phytochemistry

Key bioactive constituents of *O. sanctum* include eugenol (responsible for anti-inflammatory and analgesic effects), ursolic acid (anti-inflammatory, anti-stress), rosmarinic acid (antioxidant, anti-inflammatory), ocimumosides A and B (anti-stress), cerebrosides, and fixed and volatile oils. The eugenol content of tulsi essential oil ranges from 70–96% depending on the variety and growing conditions.

Pharmacological Evidence

Anti-stress and adaptogenic effects represent the most clinically validated properties of *O. sanctum*. A mechanistic study by Jothie Richard et al. (2016), published in *Phytotherapy Research* (PubMed PMID 26899341), investigated the anti-stress potential of *O. sanctum* using a chronic variable stress paradigm in rats. The study demonstrated that *O. sanctum* was effective in managing stress effects through inhibition of cortisol release, blocking of the CRHR1 receptor, and inhibition of 11 β -HSD1 and COMT activities —

together constituting a comprehensive HPA axis modulation mechanism.

A 2022 randomized, double-blind, placebo-controlled trial published in *Frontiers in Nutrition* examined the effects of a standardized *Ocimum tenuiflorum* extract (Holixer™) on stress, mood, and sleep quality in adults experiencing stress. The trial reported significant reductions in perceived stress scores, improvements in sleep quality, and modulation of stress biomarkers in the treatment group. The study identified a comprehensive evidence base from 24 earlier clinical trials supporting tulsi's adaptogenic, neuroendocrine, and immunomodulatory effects.^[6]

An extensive narrative review by Srivastava and Singh (2021), published in the *Auctores Journal of Clinical Research Notes*, confirmed that standardized extracts of *O. tenuiflorum* can significantly reduce perceived stress levels, decrease cortisol production, and enhance sleep quality in healthy adults. Animal studies consistently demonstrate reductions in stress-induced ulceration, adrenal gland hypertrophy, and plasma corticosterone levels. The review further confirmed tulsi's antimicrobial, anti-viral, and immunomodulatory properties.

Safety and Dosage

Tulsi is widely consumed as a herbal tea and supplement with an established safety profile. Clinical trials have used doses of 500–1000 mg/day of standardized extract. Tulsi possesses mild anticoagulant properties, and patients on blood-thinning medications should exercise caution.

Zingiber officinale (Ginger)-*Zingiber officinale* Roscoe belongs to the family Zingiberaceae. The rhizome (underground stem) is the part used therapeutically and culinarily. Ginger has been used in Ayurvedic medicine as Shunthi (dry ginger) and Adraka (fresh ginger) and is classified as one of the most important spices with digestive-stimulating, anti-inflammatory, and analgesic properties.

Phytochemistry

The primary bioactive compounds of *Z. officinale* are gingerols (especially 6-gingerol) and shogaols (formed from gingerols upon heating/drying), which are responsible for the characteristic pungency and most pharmacological effects. Additional constituents include paradols, zingerone, gingerdiones, terpenes (zingiberene, β -bisabolene), and flavonoids.^[6]

PHARMACOLOGICAL EVIDENCE

Anti-inflammatory and analgesic effects of ginger in the context of physical performance have been rigorously demonstrated. A landmark double-blind, placebo-controlled study by Black et al. (2010), published in *The Journal of Pain* (ScienceDirect, PMID 20418184), examined 11 days of raw and heat-treated ginger supplementation on muscle pain following eccentric exercise in 74 volunteers. Both raw (25% pain reduction, $P = 0.041$) and heat-treated (23% reduction, $P = 0.049$) ginger produced significant muscle pain reductions 24 hours after eccentric exercise, compared to placebo.

A 2025 study in *Nutrients* (MDPI) investigated the effects of a specialized ginger extract on pain perception, functional capacity, and markers of inflammation in individuals experiencing joint and muscle pain. Ginger supplementation (125 mg/day, providing 12.5 mg/day of gingerols) demonstrated favorable effects on pain perceptions, functional capacity, and inflammatory markers in the treatment group compared to placebo, registered under clinical trial ISRCTN74292348.

A 2024 critical review in *Frontiers in Nutrition* assessed ginger's antioxidant, anti-inflammatory, and

immunomodulatory activities. The review confirmed that gingerols and shogaols suppress pro-inflammatory cytokines (TNF- α , IL-6, IL-1 β) and inhibit cyclooxygenase (COX) enzymes, providing a mechanistic basis for observed clinical anti-inflammatory effects. A separate study in endurance-trained athletes found that 6 weeks of ginger supplementation reduced pro-inflammatory cytokine levels by 20–45% compared to placebo following treadmill testing.

Safety and Dosage

Ginger is classified as GRAS (Generally Recognized As Safe) by the US FDA and is widely used as a culinary spice. Therapeutic doses of 1–3 g/day of dried ginger powder are well-established. High doses may cause mild GI discomfort. Patients on anticoagulant therapy should consult a physician given ginger's mild blood-thinning properties.^[7]

Synergistic Effects and Polyherbal Rationale

The Concept of Polyherbalism in Ayurveda—The concept of combining multiple herbs in Ayurvedic formulations is well-established and documented in classical texts. The Ayurvedic literature Sarangdhara Samhita (1300 AD) first articulated the principle of polyherbalism — that combining herbs in specific ratios achieves therapeutic outcomes superior to any individual herb used alone. A PMC review (PMC4127824) on polyherbal formulation concepts confirmed that individual plants' active phytochemical constituents are often present in insufficient quantities to achieve desired therapeutic effects alone, and that synergistic herb-herb interaction — known as 'positive herb-herb interaction' — produces greater results than the sum of individual effects. Formulations confer benefits unavailable in single-herb preparations, including enhanced therapeutic effect, reduced required dose (thus reducing toxicity risk), and improved patient convenience. Synergism operates through both pharmacodynamic mechanisms (complementary mechanisms of action) and pharmacokinetic mechanisms (enhancement of absorption and bioavailability).

Synergistic Interactions in the Blend

Dual Adaptogenic Synergy: Ashwagandha + Tulsi—Both *Withania somnifera* and *Ocimum sanctum* are classified as primary adaptogens — herbs that modulate the HPA axis to reduce cortisol and manage physiological stress responses. *W. somnifera* acts primarily through withanolides modulating HPA axis feedback, while *O. sanctum*'s ursolic acid inhibits the CRHR1 receptor and reduces cortisol production through distinct mechanisms (COMT and 11 β -HSD1 inhibition). The dual targeting of the stress response cascade by two complementary mechanisms results in enhanced anti-stress and anti-fatigue outcomes beyond what either herb achieves independently.^[8]

Immune Potentiation: Giloy + Amla—*Tinospora cordifolia* and *Phyllanthus emblica* act synergistically on immune enhancement through distinct but complementary pathways. Giloy activates cell-mediated immunity, phagocytosis stimulation, and NF- κ B pathway modulation, while Amla's high Vitamin C content and polyphenols provide antioxidant support that prevents oxidative damage to immune cells, thus sustaining the immune response. Their combination creates a comprehensive 'activate and protect' immunological effect.

Anti-Inflammatory Stack: Ashwagandha + Ginger

Withania somnifera and *Zingiber officinale* both possess anti-inflammatory properties through COX enzyme inhibition, but operate via different molecular targets. Ashwagandha withanolides modulate NF- κ B and HSP70 stress proteins, while ginger's gingerols/shogaols directly suppress prostaglandin synthesis. Their combination provides broader anti-inflammatory coverage particularly relevant for exercise recovery and post-workout muscle soreness.

Bioavailability Enhancement: Black Pepper (Piperine)

The inclusion of black pepper (*Piper nigrum*) as a bioenhancer in the formulation has strong scientific support. Piperine — the primary alkaloid of black pepper — was first scientifically validated as the world's first bioavailability enhancer in 1979 by scientists at the Regional Research Laboratory, Jammu (now Indian Institute of Integrative Medicine), as documented in a PMC review (PMC3634921). Piperine enhances absorption from the gastrointestinal tract by modulating membrane dynamics, increasing intestinal permeability, and inhibiting key metabolizing enzymes including P-glycoprotein, CYP3A4, and UDP-glucose dehydrogenase. A PMC review (PMC3458266) demonstrated that co-administration of piperine (20 mg) with curcumin increased bioavailability by 200% in humans, and similar enhancing effects have been documented for phenytoin, ampicillin, metronidazole, and various herbal compounds. This evidence strongly supports piperine as a critical additive in the formulation to maximize the bioavailability of all five herb constituents

Nutraceutical Classification and Regulatory Framework

Definition and Classification

The term 'nutraceutical' was coined by Dr. Stephen DeFelice in 1989, combining 'nutrition' and 'pharmaceutical' to describe food-derived substances that provide health benefits beyond basic nutrition. In India, nutraceuticals are governed by a specific regulatory framework distinct from both conventional foods and drugs.

The relevant regulatory authority is the Food Safety and Standards Authority of India (FSSAI). As per a USDA Foreign Agricultural Service analysis (2022), FSSAI issued directive Std/SP-05/T(Nutraceutical-2022) which overhauled the previous 2016 framework and established the FSS (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose and Prebiotic and Probiotic Food) Regulations, 2022. This framework was re-operationalized with effect from 01.01.2024 under a direction issued by FSSAI on 5th June 2024. **Product Classification**

Under the FSS Nutra Regulations 2022, the Blend may be classified as either a Health Supplement (a product containing vitamins, minerals, amino acids, botanicals, or enzymes intended to supplement the diet) or a Nutraceutical (a purified or extracted food-based product with physiological benefits). The product's composition — containing five FSSAI-approved botanical ingredients in food-grade form — qualifies it for Health Supplement classification, which carries the lowest regulatory burden. According to a 2024 analysis published by Cyril Amarchand Mangaldas (corporate.cyrilamarchandblogs.com), products under Nutra Regulations 2022 are explicitly prohibited from claiming to treat, cure, or prevent any disease — claims must be limited to general wellness and structure/function benefits.^[9]

Permitted vs. Prohibited Claims

Permitted claims for a Health Supplement classification include: 'supports immunity,' 'helps maintain energy levels,' 'promotes vitality and physical wellness,' 'helps reduce fatigue,' 'supports the body's natural stress response,' and 'contributes to overall wellbeing.' **Prohibited claims** include: 'treats chronic fatigue syndrome,' 'cures arthritis,' 'prevents infection,' 'diagnoses or mitigates any disease.' The label must prominently display: 'Not intended to diagnose, treat, cure or prevent any disease.'

Licensing Pathway

As per the FoSCoS (Food Safety Compliance System) portal guidelines, manufacturers must obtain: (1) FSSAI State License (for manufacturing units with annual turnover between INR 12 lakh and INR 20 crore), (2) product-specific approval confirming ingredient compliance with FSSAI-approved ingredient schedules, and (3) GMP (Good Manufacturing Practice) certification compliance. The product label must include: product name, ingredient list with quantities, net weight/volume, nutritional information per serving, manufacturer details with FSSAI license number, best-before date, batch number, directions for use, storage instructions, and the mandatory disclaimer.^[10,11]

MARKET RELEVANCE AND CONSUMER LANDSCAPE

India's nutraceutical market has undergone transformative growth over the past decade. According to IMARC Group (2024), the Indian nutraceutical market was valued at USD 8.00 billion in 2024 and is projected to reach USD 21.48 billion by 2033, growing at a CAGR of 11.60%. The market has been shaped by several converging forces: post-COVID immunological awareness, rising prevalence of lifestyle diseases, increasing health consciousness, and India's deep cultural heritage in Ayurvedic wellness.

The Ayurvedic health drinks segment is particularly relevant to this formulation. The India Ayurvedic health drinks market was valued at USD 1.1 billion in 2024 and is projected to reach USD 2.7 billion by 2033 at a CAGR of 11% (IMARC Group, 2024). Market research highlights that formulations combining traditional Ayurvedic herbs — specifically Ashwagandha, Tulsi, Amla — with scientific evidence are gaining significant consumer traction. Industry giant Zydus Wellness launched Complian Immuno-Gro in 2024, a formulation incorporating over 20 Ayurvedic herbs including Amla and Ashwagandha, validating the commercial viability of this product category.^[12,13]

The India Ayurvedic products market was valued at USD 9,171.12 million in 2024 and is projected to grow at a CAGR of 16.33% through 2033 (Univdatos, 2024). The Indian herbal nutraceutical segment alone is projected to reach USD 10 billion by 2027, growing at a 21% CAGR (Sourceready, 2026). Over 65% of Indian consumers prefer plant-based medicines due to growing awareness of synthetic drug side effects, creating a highly receptive consumer base for the Blend.

The ready-to-drink Ayurvedic beverage format specifically addresses a gap in the market. While traditional herbs are widely available as tablets and capsules, the instant drink format addresses consumer preferences for convenience, rapid preparation, and sensory experience. Growing collaborations between Ayurvedic brands and fitness/wellness influencers, alongside increasing sports nutrition awareness, position the Blend at the intersection of multiple high-growth market segments.^[14,15]

RESEARCH GAPS AND JUSTIFICATION FOR THE BLEND

Despite substantial individual evidence for each of the five botanical ingredients, the following research gaps provide compelling justification for the development of the Blend as a novel polyherbal nutraceutical formulation:

Gap 1 — Absence of clinical evidence for this specific 5-herb combination: While the individual ingredients have been extensively studied, no published clinical trial has examined the specific combination of *W. somnifera*, *T. cordifolia*, *P. emblica*, *O. sanctum*, and *Z. officinale* as a unified formulation. The synergistic interactions described in Section 3 are largely inferred from individual studies and polyherbal theory, creating an evidence gap that this formulation can address.

Gap 2 — Limited research on instant-drink delivery formats: The vast majority of Ayurvedic herb research has been conducted using capsule or tablet delivery systems. The instant-drink format presents unique bioavailability, stability, and sensory consideration requiring dedicated research. The absence of peer-reviewed formulation studies on this delivery mode represents a scientific gap.

Gap 3 — Underrepresentation of combined physical-immune-stress outcomes: Most existing studies assess either physical performance OR immune function OR stress reduction in isolation. The Blend targets all three simultaneously, recognizing that these are interconnected biological systems. No existing product or study addresses this trifecta within a single standardized formulation.

Gap 4 — Limited standardization of polyherbal Ayurvedic nutraceuticals: Commercial Ayurvedic products frequently lack standardization for active compound content (e.g., withanolide percentage, emblicanin content). Developing a standardized formulation with defined bioactive thresholds would represent a significant contribution to the field and align with FSSAI's evolving quality standards.

Gap 5 — Piperine as bioenhancer in polyherbal blends: While piperine's bioenhancing effects are well-documented for individual compounds, its role in simultaneously enhancing the bioavailability of multiple herbs in a polyherbal formulation has not been formally characterized. This represents an important mechanistic investigation opportunity.

These research gaps collectively justify the development, formulation, and systematic investigation of the Blend — an evidence-based, FSSAI-compliant, instant-drink nutraceutical positioned to meet documented consumer demand while filling critical scientific knowledge gaps.

CONCLUSION

This literature review has established a comprehensive scientific foundation for the Blend across six dimensions: individual ingredient pharmacology, synergistic interactions, regulatory compliance, market opportunity, and research justification. The five ingredients — *Withania somnifera*, *Tinospora cordifolia*, *Phyllanthus emblica*, *Ocimum sanctum*, and *Zingiber officinale* — each carry robust peer-reviewed evidence supporting their roles in physical performance enhancement, fatigue reduction, immune modulation, anti-inflammatory activity, and stress management.

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The polyherbal formulation principle, well-established in Ayurvedic literature and validated by modern pharmacological science, provides theoretical and mechanistic justification for expecting synergistic benefits from this specific combination. The addition of black pepper (piperine) as a bioavailability enhancer — scientifically validated since 1979 — further strengthens the formulation's scientific basis. The Indian nutraceutical regulatory framework under FSSAI's FSS Nutra Regulations 2022 provides a clear compliance pathway for the product as a Health Supplement, with well-defined permitted claims aligned with the formulation's demonstrated benefits. The market context — a USD 8 billion and rapidly growing Indian nutraceutical sector with strong Ayurvedic consumer preference — confirms both the commercial viability and the timeliness of this product.

Taken together, the evidence reviewed herein strongly supports the scientific credibility, regulatory feasibility, and commercial relevance of the Blend as a novel Ayurvedic nutraceutical instant drink.

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