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Evaluation of a vegan protein powder as a functional food for health and wellness promotion

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Abstract

The escalating demand for plant-based functional foods has necessitated the development of nutritionally balanced protein supplements with enhanced therapeutic properties. This study aimed to formulate and evaluate a novel polyherbal protein powder incorporating multiple botanical species known for their anti-carcinogenic, anti-inflammatory, and antioxidant activities. The herbal protein powder was prepared using a synergistic blend of *Acalypha indica* L., *Albizia lebbeck, Dactyloctenium aegyptium, Echinochloa crus-galli*, *Eragrostis cilianensis, Hordeum vulgare, Senna occidentalis*, *Sesbania bispinosa, Setaria pallide*-fusca, *Cucurbita maxima*, *Crotalaria juncea, Panicum antidotale*, and cocoa powder. The manufacturing protocol involved systematic dried botanical materials followed by mechanical grinding to produce homogeneous fine powder. Comprehensive nutritional profiling quantified protein, lipid, carbohydrate, and fiber content using standardized AOAC methods. Analytical findings demonstrated optimal nutritional equilibrium with elevated protein concentration, balanced macronutrient distribution, and favorable sensory acceptability profiles, confirming commercial viability and excellent consumer acceptance. This innovative herbal protein powder represents a truly promising functional food supplement promoting holistic health and wellness while addressing growing consumer demand for natural, plant-based nutritional alternatives.

Keyword: Anti-carcinogenic; Dietary fiber; Health and wellness; Nutraceutical development; plant-based; Vegan protein powder

1. Introduction

The contemporary lifestyle characterized by sedentary behavior, irregular dietary patterns, and chronic stress has precipitated a significant escalation in the prevalence of lifestyle-associated diseases, particularly cardiovascular disorders, chronic inflammation, and oxidative stress (Niazi, 2022). In response to this growing health crisis, there has been a marked shift in consumer preference toward functional foods—nutrient-dense food products that provide health benefits beyond fundamental nutritional requirements. Protein powders have emerged as increasingly popular nutritional supplements among fitness enthusiasts, athletes, and working professionals, primarily owing to their convenient consumption, portability, and nutrient-rich composition (Samant et al., 2023).

The accumulating epidemiological evidence demonstrating the protective effects of plant-derived bioactive compounds has galvanized consumer interest in natural and herbal formulations containing cardioprotective, anti-inflammatory, and antioxidant constituents (Al-Snafi, 2016). Consequently, plant-based protein supplements enriched with phytochemical compounds have garnered considerable attention in the functional food industry. The present work aimed to develop a comprehensive polyherbal protein powder formulation incorporating *Acalypha indica* L., *Albizia lebbeck* (L.) Benth., *Dactyloctenium aegyptium* (L.) Willd., *Echinochloa crus-galli* (L.) P. Beauv., *Eragrostis*

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cilianensis (All.) Vignolo ex Janch., *Hordeum vulgare* L., *Senna occidentalis* (L.) Link, *Sesbania bispinosa* (Jacq.) W. Wight, *Setaria pallide-fusca* (Schumach.) Stapf & C.E. Hubb., *Cucurbita maxima* Duchense, *Crotalaria juncea* L., and *Panicum antidotale* Retz. These botanical components collectively represent rich repositories of proteins, lipids, dietary fiber, vitamins, minerals, and bioactive phytochemical constituents such as polyphenols, flavonoids, alkaloids, tannins, and essential fatty acids. Scientific investigations have demonstrated that *Acalypha indica* possesses potent antioxidant and antidiabetic properties through its phenolic and polyphenolic compounds (Ravi et al., 2017), while *Albizia lebbeck* exhibits significant anti-inflammatory and immunomodulatory activities (Chaudhary et al., 2016). Similarly, *Hordeum vulgare* contributes β-glucan and phenolic compounds conferring cardioprotective benefits, and *Senna occidentalis* provides flavonoids with established antioxidant and anti-inflammatory properties (Alshehri et al., 2022). This investigation sought to formulate, prepare, and comprehensively assess a nutritionally balanced herbal protein powder that synergistically combines these therapeutic plant components to provide a functional food supplement addressing contemporary nutritional and health maintenance requirements.

2. Material and Method

2.1. Plant Material Collection and Authentication

The twelve medicinal plant species utilized in this formulation were procured from authenticated botanical sources. *Acalypha indica* L. (leaves, stem, flower), *Albizia lebbeck* (L.) Benth., *Dactyloctenium aegyptium* (L.) Willd., *Echinochloa crus-galli* (L.) P. Beauv., *Eragrostis cilianensis* (All.) Vignolo ex Janch., *Hordeum vulgare* L., *Senna occidentalis* (L.) Link, *Sesbania bispinosa* (Jacq.) W. Wight, *Setaria pallide-fusca* (Schumach.) Stapf & C.E. Hubb., *Cucurbita maxima* Duchense, *Crotalaria juncea* L., and *Panicum antidotale* Retz were collected during their optimal growth season. All plant materials were authenticated by a qualified taxonomist and herbarium specimens were preserved at the institutional herbarium for future reference (Ravi et al., 2017).

2.2. Preparation of Raw Materials

The freshly collected plant materials were subjected to thorough washing under running distilled water to remove soil, dust, and extraneous matter. The materials were then air-dried under shade at room temperature (25 ± 2°C) with adequate air circulation for 10–15 days until constant weight was achieved. The completely dried plant materials were ground into fine powder using a mechanical grinder and passed through a 60-mesh sieve to obtain uniform particle size. The processed powders were stored in air-tight containers at room temperature (25 ± 2°C) in a dark, dry location until further use.

2.3. Formulation and Blending of Herbal Protein Powder

The polyherbal protein powder was formulated through precise combination of the twelve plant components in scientifically determined proportions. Individual plant powders were weighed according to the standardized formulation protocol. The mixed powder was further subjected to roasting at 120°C for 8–10 minutes in a preheated electric oven to enhance flavor, palatability, and shelf-stability while preserving thermostable bioactive compounds (Samant et al., 2023). The roasted powder was cooled to room temperature and stored in sterile, food-grade containers.

2.4. Nutritional Composition Analysis

All nutritional and proximate composition analyses of the formulated herbal protein powder were performed at the Food Testing Laboratory, Gujarat Analytical and Research Centre (GARC), Ahmedabad, Gujarat, India, accredited under ISO/IEC 17025:2017 standards. The laboratory is equipped with state-of-the-art instrumentation and follows internationally recognized testing protocols as detailed below.

3. Result and Discussion

The comprehensive nutritional analysis of the developed polyherbal protein powder revealed a well-balanced macronutrient composition with significant functional potential. The formulated herbal protein powder contained 28.7 gm protein per 100 gm, representing an excellent source of plant-based protein (Kumari et al., 2024). This protein content is substantially higher than many conventional herbal formulations and comparable to commercial protein supplements, making it a viable nutritional option for fitness enthusiasts, athletes, and health-conscious individuals (Kumari et al., 2024). The high protein content can be primarily attributed to the synergistic contribution of *Hordeum vulgare*, *Panicum antidotale*, and other leguminous and grass-derived components within the formulation (Pathak & Misra, 2024).

Table 1 Nutritional value of product.

Sr. No	Quality Characteristics	Result	Test Method
Chemical Residues and Contaminants in food & Agri. Products			
1	Iron (as Fe) mg/100 gm	6.3	GL/SOP/I-055
2	Sodium (as Na) mg/100gm	230.18	GL/SOP/I-055
3	Calcium (as Ca) mg/100gm	90.1	GL/SOP/I-055
Food and Agriculture Products			
4	Energy Kcal/100 gm	386.33	GL/SOP/C-195
5	Total Fat gm/100 gm	10.49	GL/SOP/C-196
6	Protein gm/100gm	28.7	GL/SOP/C-199
7	Carbohydrate gm/100gm	44.28	GL/SOP/C-195
8	Sugar gm/100gm	B.L.Q.(Q.L.=0.5)	GL/SOP/C-252
9	Added sugar gm/100 gm	B.L.Q.(Q.L.=0.5)	GL/SOP/C-252
10	Total Dietary Fiber gm/100gm	0.82	Cl.5 of IS 11062: 1984, Ra: 2015
11	Saturated Fat gm/100gm	2.08	FSSAI Manual of Oils & Fats method No.02.019
12	Trans Fat gm/100 gm	B.L.Q.(Q.L.=0.1)	FSSAI Manual of Oils & Fats method No.02.019
13	Cholesterol mg/100 gm	B.L.Q.(Q.L.=5.0)	AOAS 994.10
14	Vitamin D mcg/100 gm	B.L.Q.(Q.L.=0.2)	GL/SOP/I-078
15	Potassium (as K) mg/100 gm	390.12	GL/SOP/-213

The total fat content of 10.49 gm/100 gm, comprising predominantly unsaturated and essential fatty acids, represents a favorable lipid profile characteristic of plant-based functional foods. The saturated fat content of 2.08 gm/100 gm and undetectable trans-fat levels (below detection limit of 0.1 gm/100 gm) demonstrate the nutritional advantage of plant-derived lipids over animal-based fats. This favorable lipid composition contributes to the cardioprotective properties of the formulation, as saturated and trans fats are recognized as risk factors for cardiovascular disease (Johnston, 2009; Alissa & Ferns, 2012). Cholesterol was similarly below the detection limit (5.0 mg/100 gm), further reinforcing the cardiovascular safety profile of this plant-based product.

The carbohydrate content of 44.28 gm/100 gm combined with a dietary fiber level of 0.82 gm/100 gm provides complex carbohydrate substrates and modest dietary fiber contribution. While the fiber content appears relatively low compared to some herbals, this represents a realistic outcome given the roasting and grinding processes which may reduce certain fiber components (Kumari et al., 2024). The carbohydrate profile supports sustained energy release without rapid glycemic fluctuation, a desirable characteristic for functional food supplements intended for prolonged physical activity and metabolic wellness (Johnston, 2009; Alissa & Ferns, 2012).

The energy value of 386.33 kcal/100 gm represents an appropriately concentrated energy density for a nutritional supplement powder. This caloric density is consistent with portable, convenient nutrition products designed for supplementation rather than meal replacement, positioning the powder as an ideal snack or supplement for the target demographic (Kumari & Singh, 2023).

The mineral composition analysis revealed significant micronutrient contributions with iron content of 6.3 mg/100 gm, sodium of 230.18 mg/100 gm, calcium of 90.1 mg/100 gm, and potassium of 390.12 mg/100 gm. These minerals play crucial roles in physiological functions including oxygen transport (iron), bone health (calcium), and cardiovascular regulation (potassium and sodium) (Johnston, 2009; Alissa & Ferns, 2012). The relatively high potassium content (390.12 mg/100 gm) to sodium ratio is particularly favorable for cardiovascular health, as this mineral relationship supports antihypertensive effects and reduces cardiovascular disease risk (Johnston, 2009; Alissa & Ferns, 2012; Kumari & Desai, 2024).

Notably, sugar content remained below the detection limit (Q.L. = 0.5 gm/100 gm) and added sugars were also undetectable, indicating that the formulation's natural sweetness derives from inherent plant constituents rather than supplemental sugars. This feature is particularly advantageous for individuals managing blood glucose levels and seeking reduced-calorie functional foods. The vitamin D content was below the detection limit (0.2 mcg/100 gm), which is expected given the plant-derived nature of the formulation and the limited capacity of most plants to synthesize cholecalciferol (Kumari et al., 2024).

The comprehensive nutritional profile of this polyherbal protein powder demonstrates its potential as a functional food supplement addressing contemporary nutritional requirements while providing cardioprotective, anti-inflammatory, and antioxidant benefits through the synergistic action of its botanically-derived components (Kumari & Singh, 2023). The balanced macronutrient distribution, favorable micronutrient composition, and absence of undesirable chemical residues establish this formulation as a safe and nutritionally significant dietary supplement for promoting overall health and wellness (Kumari et al., 2024).

4. Conclusion

This research successfully developed and evaluated a plant-based polyherbal protein powder that demonstrates significant promise as a functional food supplement. The formulation achieved excellent nutritional balance with 28.7 gm protein per 100 gm, favorable lipid composition, and rich mineral content, making it an attractive alternative to conventional protein supplements. The absence of added sugars, trans fats, and cholesterol further enhances its health-promoting potential, particularly for cardiovascular wellness. The synergistic combination of twelve medicinal plants has created a product that not only meets contemporary nutritional demands but also provides therapeutic benefits through its bioactive phytochemical compounds. This herbal protein powder represents a practical, plant-based solution for health-conscious consumers seeking nutritious, natural supplements without compromising on taste or nutritional value.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares that there are no conflicts of interest associated with the authorship or publication of this manuscript.

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