Comparative Phytochemical Profiling of Improved and Local Hyacinth Bean (*Lablab purpureus L.*) Varieties

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Abstract

Hyacinth bean (*Lablab purpureus L.*), is a significant leguminous crop valued for its phytochemical and nutritional qualities. The total phenolic content (TPC), total flavonoid content (TFC), and qualitative phytochemical composition of pods and seeds from certain improved BARI cultivars and regional hyacinth bean varieties collected from Bangladesh were compared in this study. While TPC and TFC were measured spectrophotometrically using Folin–Ciocalteu and aluminum chloride colorimetric techniques, respectively, methanolic extracts of pod and seed samples were submitted to qualitative phytochemical screening using standard methods. The majority of the studied varieties exhibited a number of significant secondary metabolites, including steroids, saponins, terpenoids, coumarins, and sugars, according to qualitative research. The varieties exhibited significant differences in TPC and TFC ($p < 0.05$). In comparison to seed extracts, pod extracts often showed significantly higher phenolic and flavonoid concentrations. Bata Sheem had the greatest TFC (723.0 ± 8.0), and BARI-8 had the highest TPC (30.13 ± 0.28) among the pod samples. Jackbean had the highest TPC (7.62 ± 0.11) and BARI-6 had the highest TFC (0.73 ± 0.03) in seed extracts. Local varieties showed relatively high phytochemical accumulation, suggesting that they might possess nutritional and functional benefits. The results emphasize the value of native hyacinth bean germplasm as a potential source of functional food components and bioactive phytochemicals.

1. Introduction

In tropical and subtropical areas, the hyacinth bean (*Lablab purpureus L.*), a significant multipurpose leguminous crop in the *Fabaceae* family, is grown extensively for its edible pods, dry seeds, fodder, forage, and green manure applications. The crop is valued for its nutritional value, broad genetic diversity, and capacity to address a variety of environmental situations (Maass et al., 2010). Due to its high economic value and widespread consumer popularity, hyacinth beans are widely grown throughout Bangladesh. Both traditional varieties like Jackbean and improved cultivars produced by the Bangladesh Agricultural Research Institute (BARI), such as BARI Seem-5, BARI Seem-6, and BARI Seem-8, show significant variation in morphology, yield performance, and biochemical composition.

Protein, complex carbohydrates, dietary fiber, vitamins, and important minerals, including calcium, magnesium, phosphorus, and iron can all be found in hyacinth bean pods and seeds (Mortuza & Tzen, 2009). In addition to their nutritional significance, hyacinth bean tissues contain several bioactive phytochemicals including phenolic compounds, flavonoids, saponins, terpenoids, steroids, and coumarins. According to Balasundram et al. (2006), these secondary metabolites have antibacterial, anti-inflammatory, antioxidant, and other health-promoting qualities. Because of its ability to scavenge free radicals and lessen diseases associated with oxidative stress, phenolic compounds and flavonoids are especially significant.

The concentration and distribution of phytochemicals may fluctuate between cultivars and between other plant parts, such as pods and seeds, due to genetic and physiological variations. While pods are metabolically active tissues that are immediately exposed to environmental stress, seeds serve mainly as storage organs. As a result, differences in phenolic and flavonoid accumulation between pods and seeds may affect their potential as functional foods and their antioxidant qualities.

Due to their flexibility, consumer demand, and environmental tolerance, traditional native hyacinth bean types remain widely grown throughout Bangladesh. When compared to developed cultivars, these native germplasms might have distinct phytochemical and nutritional traits. According to earlier research, local landraces often contain higher levels of micronutrients and phenolic compounds due to their long-term environmental adaptation and greater genetic diversity. In order to find nutritionally superior genotypes and support the conservation of native plant genetic resources, it is crucial to compare improved BARI cultivars with local variations.

Despite the hyacinth bean's nutritional and therapeutic value, there is currently limited information comparing the phytochemical traits of the seeds and pods from various varieties. In order to compare the qualitative phytochemical composition, the present study aimed to compared the qualitative phytochemical composition, total phenolic content, and total flavonoid content of pods and seeds from certain enhanced BARI cultivars and regional hyacinth bean varieties, the current study was conducted.

2. Materials and Methods

2.1 Experimental Design

A total of six hyacinth bean (*Lablab purpureus L*.) varieties comprising four improved BARI cultivars and two local landraces were selected for comparative phytochemical evaluation. The investigated cultivars included BARI-5, BARI-6, BARI-8, Jackbean, Puti Sheem, and Bata Sheem.

2.2 Sample collection and preparation

Mature seeds and pods of four hyacinth bean (*Lablab purpureus L*.) cultivars, **BARI 5, BARI 6, BARI 8, and Jackbean**, were collected from the Bangladesh Agricultural Research Institute (BARI). Two local hyacinth bean types named “Puti Sheem” and “Bata Sheem” were collected from Chattogram, Bangladesh's local vegetable markets, for comparative phytochemical analysis. The plant material used in this study is the entire collection of food crops. The plant material was collected following respective institutional and national laws. No protected or endangered plant species were impacted.

The collected samples were thoroughly washed with distilled water to remove surface impurities and subsequently shade-dried. The samples were then oven-dried at 40–45°C until constant weight was achieved. Dried samples were ground into fine powder using a sterile grinder and stored in airtight containers for further analysis.

10 g of powdered material and 100 mL of 80% methanol were combined for extraction, and the mixture was continuously shaken for 48 hours at room temperature. The extracts were concentrated in a water bath kept at 40–45°C after being filtered through Whatman No. 1 filter paper. Until further phytochemical studies were conducted, the crude extracts were stored at 4°C.

2.3 Qualitative Phytochemical Analysis

Major secondary metabolites, such as steroids, saponins, flavonoids, terpenoids, coumarins, and carbohydrates, have been identified by qualitative phytochemical analysis of the total six hyacinth bean varieties comprising four improved BARI cultivars and two local landraces, pod and seed extracts using standard methods described by Harborne (1998) and Evans (2009).

2.3.1 Test for steroids: Concentrated sulfuric acid (H2SO4) had been added to the methanolic extract. Steroids were detected by the formation of a bluish-green ring at the interface.

2.3.2 Test for Saponins: Aqueous extract was shaken vigorously, and the presence of saponins was indicated by the formation of firm, persistent foam.

2.3.3 Test for Terpenoids: When concentrated H2SO4 was added to the chloroform extract, a reddish-brown interface formed, indicating the presence of terpenoids.

2.3.4 Test for Coumarin: Ethanolic extract was treated with dilute hydrochloric acid, and blue-green fluorescence indicated the presence of coumarins.

2.3.5 Carbohydrate analysis: Iodine, Benedict's, and Molisch's tests were used to identify starch, reducing sugars, and basic carbohydrates, respectively.

2.4 Quantitative Phytochemical Analysis

2.4.1 Determination of Total Phenolic Content (TPC): According to Singleton et al. (1999), the Folin–Ciocalteu colorimetric method was used to calculate the total phenolic content. In brief, the Folin-Ciocalteu reagent, sodium carbonate solution, and plant extract were combined, and the mixture was then incubated in the dark. A UV-visible spectrophotometer was used to measure absorbance. Gallic acid equivalent (GAE) mg/g extract was used to express the total phenolic content.

2.4.2 Determination of Total Flavonoid Content (TFC): The aluminum chloride colorimetric method described by Chang et al. (2002) was used to assess the total flavonoid content. After mixing the extract with an aluminum chloride solution, the absorbance was measured at 415 nm using spectrophotometry. The expression for total flavonoid content was mg quercetin equivalent (QE)/g of extract.

2.5 Statistical Analysis

The data were presented as mean ± standard deviation (SD), and all quantitative analyses were performed in triplicate. One-way analysis of variance (ANOVA) and Microsoft Excel 2019 was used for statistical analysis and to determine significant differences among the Hyacinth bean varieties. Mean differences were considered significant at $p < 0.05$.

3. Results and discussion

3.1 Phytochemical screening of hyacinth bean seeds: Both the pod and seed extracts of the hyacinth bean types under study included several significant secondary metabolites, according to qualitative phytochemical analysis. The majority of the samples contained steroids, saponins, terpenoids, coumarins, and sugars, suggesting significant phytochemical variety across the cultivars, as summarized in Table 1.

Table 1
Qualitative phytochemical screening of pod and seed extracts of improved and local hyacinth bean (*Lablab purpureus L.*) varieties.

Variety	Steroids	Saponins	Flavonoids	Terpenoids	Coumarins	Molisch's	Benedict's	Iodine
BARI 5	+	+	+	+	+	+	–	+
BARI 6	+	+	+	+	+	+	–	+
BARI 8	+	+	+	+	+	+	–	+
Jackbean	+	+	+	+	+	+	–	+
Puti Sheem (S)	+	+	+	+	+	+	–	+
Bata Sheem (L)	+	+	+	+	+	+	–	+

(+) = presence; (–) = absence of phytochemical compounds. Qualitative phytochemical screening was performed following standard procedures described by Harborne (1998*) and* Evans (2009*).*

The development of a bluish-green ring after sulfuric acid treatment was used to indicate the presence of steroids, whereas the presence of saponins was confirmed by continuous foam formation. In acidic environments, coumarins were confirmed by blue-green fluorescence, while terpenoids were identified by the appearance of a reddish-brown interface. Benedict's test revealed negative findings for the majority of samples, indicating a low reducing sugar content, whereas positive Molisch's and iodine tests verified the existence of carbohydrates and starch in the extracts. These results imply that physiologically active phytochemicals found in both local and modified hyacinth bean cultivars may contribute to their antioxidant and health-promoting qualities.

Genetic variation, environmental adaptation, and physiological differences amongst plant tissues may be linked to the phytochemical variety observed among the cultivars. The production of protective secondary metabolites may be promoted by the various environmental factors that local landraces are frequently exposed to.

3.2 Total Phenolic Content (TPC): The total phenolic content of the hyacinth bean types under study varied significantly across the pod and seed samples (Table 2). Pod extracts showed much higher phenolic levels than seed extracts in all similar cultivars.

The pod samples with the highest phenolic content were BARI-8 (30.13 ± 0.28), followed by Puti Sheem (27.13 ± 0.68), Jackbean (22.16 ± 0.63), BARI-5 (20.91 ± 0.11), Bata Sheem (20.9 ± 0.15), and BARI-6 (17.95 ± 0.28). Seed samples, on the other hand, showed slightly lower phenolic contents. Jackbean had the greatest phenolic content (7.62 ± 0.11), followed by Puti Sheem (7.52 ± 0.03), whereas BARI-8 showed the lowest value (1.62 ± 0.07).

TPC varied significantly among the analyzed varieties, according to a one-way ANOVA ($p < 0.05$). The increased metabolic activity of pod tissues and their continuous exposure to external stressors, including UV radiation, infections, and oxidative stress, may be the cause of the higher accumulation of phenolic compounds in pods as compared to seeds (Vogt, 2010). In plants, phenolic compounds serve as protective metabolites and are frequently linked to free radical scavenging and antioxidant defense systems (López et al., 2013)

Genetic diversity, environmental adaptation, seed development, and pigmentation traits may also contribute to the observed variances across cultivars. Similar notable differences in phenolic accumulation between plant tissues and bean cultivars have been documented in earlier research.

Table 2
Comparative total phenolic content (TPC) and total flavonoid content (TFC) of pod and seed extracts of improved and local hyacinth bean (*Lablab purpureus L.)* varieties.

Hyacinth Bean Variety	TPC (mg GAE/g extract)		TFC (mg QE/g extract)	
	Seeds	Pods	Seeds	Pods
BARI 5	3.39 ± 0.15^{d}	20.91 ± 0.11^{e}	0.50 ± 0.01^{d}	407.7 ± 2.08^{f}
BARI 6	2.47 ± 0.06^{e}	17.95 ± 0.28^{f}	0.73 ± 0.03^{a}	663.03 ± 4.05^{c}
BARI 8	1.62 ± 0.07^{f}	30.13 ± 0.28^{a}	0.21 ± 0.01^{f}	450.3 ± 1.08^{e}
Jackbean	7.62 ± 0.11^{a}	22.16 ± 0.63^{c}	0.26 ± 0.02^{e}	698 ± 3.21^{b}
Puti Sheem (S)	7.52 ± 0.03^{b}	27.13 ± 0.68^{b}	0.53 ± 0.02^{c}	581.7 ± 2.06^{d}
Bata Sheem (L)	5.43 ± 0.10^{c}	20.9 ± 0.15^{d}	0.63 ± 0.02^{b}	723.0 ± 8.0^{a}

The mean ± standard deviation (SD) of triplicate results is used to express the values. Total phenolic content (TPC) ($F = 2193.60$, $p < 0.05$) and total flavonoid content (TFC) ($F = 409.42$, $p < 0.05$) showed significant variations between varieties according to a one-way ANOVA

3.3 Total Flavonoid Content (TFC): The studied pod and seed samples also showed differences in total flavonoid content (Table 2). Pod extracts typically showed significantly greater flavonoid contents than seed extracts, similar to phenolic content.

The pod samples with the highest flavonoid concentration were Bata Sheem (723.0 ± 8.0), followed by Jackbean (698 ± 3.21), BARI-6 (663.03 ± 4.05), Puti Sheem (581.7 ± 2.06), BARI-8 (450.3 ± 1.08), and BARI-5 (407.7 ± 2.08). The maximum flavonoid content (0.734) was found in BARI-6 (0.73 ± 0.03) seed extract, followed by Bata Sheem (0.63 ± 0.02), Puti Sheem (0.53 ± 0.02), BARI-5 (0.50 ± 0.01), Jackbean (0.26 ± 0.02), and BARI-8 (0.21 ± 0.01).

Highly significant variations in TFC between the studied varieties were found by one-way ANOVA ($p < 0.05$). Flavonoids are significant secondary metabolites found in plants that have protective, anti-inflammatory, and antioxidant properties (Panche et al., 2016) The physiological function of flavonoids in protecting against oxidative damage and environmental stress may be connected to a slightly higher concentration of flavonoids in pod tissues.

Variations in the content of flavonoids between cultivars show the biochemical variety of the hyacinth bean varieties under study (Maass et al., 2010). The cultivars' functional food value, antioxidant capacity, and nutritional quality may all be impacted by this variance.

3.4 Comparative evaluation of BARI and local varieties: The phytochemical composition and accumulation of bioactive compounds were found to differ significantly between improved BARI cultivars and local standard varieties. The variety of secondary metabolites found in both local and developed cultivars emphasizes the importance of hyacinth bean genetic resources for both nutrition and functionality.

Due to long-term environmental adaptation, local cultivars may have distinctive phytochemical traits. These native germplasms may be useful genetic resources for upcoming breeding initiatives that seek to enhance the functional qualities and nutritional value of hyacinth beans.

Overall, the results indicate that hyacinth bean seeds and pods are rich sources of bioactive phytochemicals, with pod tissues often exhibiting a higher concentration of flavonoids and phenols than seeds. The observed variation among

cultivars highlights the importance of comparative analysis for identifying genotypes that are superior in terms of nutrition.

4. Conclusions

The phytochemical composition, total phenolic content, and total flavonoid content of local and improved hyacinth bean varieties differed significantly, according to the present study. Several significant secondary metabolites, including as steroids, saponins, terpenoids, coumarins, phenols, and carbohydrates, were found in both pod and seed extracts, according to qualitative phytochemical screening.

Compared with seed extracts, pod extracts typically showed noticeably higher phenolic and flavonoid concentrations, indicating increased phytochemical accumulation in metabolically active tissues. Local landraces and Jackbean exhibited relatively higher quantities of bioactive compounds among the studied varieties, indicating their potential nutritional and functional benefits.

The results highlight the significance of native hyacinth bean germplasm as a potential source of phytochemical-rich functional foods and underscore the need to conserve and use local variations in future breeding and nutritional research.

5. Limitations

The present study was restricted to the analysis of total phenolic and flavonoid contents and qualitative phytochemical screening. There was no molecular characterization of cultivars, identification of specific beneficial components, or advanced antioxidant assessment. Additionally, the effects of seasonality and the environment on the accumulation of phytochemicals were not studied. Thus, more research with in-depth biochemical and functional analysis is needed.

6. Ethics and consent to participate

Crop varieties were cultivated with crop species obtained from Bangladesh Agricultural Research Institute (BARI) and commercial sources of local supply, Bangladesh. The use of these plant materials is in accordance with institutional and national guidelines, and they are not of a protected, endangered, or wild type. Ethical approval was not required.

Declarations

Permissions to collect the plants

The plant material used in this study was collected from cultivation and trade. Collection permit/licenses were therefore unnecessary.

Consent to publish

Not applicable

Ethical Approval

This study did not involve human participants or experimental animals. Therefore, ethical approval was not required.

Conflict of Interest

The authors declare that they do not have any conflict of interest

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process.

During the preparation of this manuscript, the authors used ChatGPT, Grammarly, and QuillBot to improve language clarity and grammar. After using these tools, the authors carefully reviewed and edited the content and take full responsibility for the final manuscript.

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Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials. Additional raw data are available from the corresponding author upon reasonable request.

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Author Approval Statement

All authors have read and approved the final version of the manuscript. Gazi Wafa Akbar had full access to all data in this study and takes full responsibility for the data's integrity and the accuracy of the analysis.

Authorship Contributions

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