

Nutrient profiling of Lablab bean [(Lablab purpureus L.) Sweet] accessions from Northeast India: Diversity exploration leading to mitigation of nutritional vulnerability

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Abstract

Lablab purpureus, one of the most significant yet neglected and underutilized legume vegetable crops, has tremendous genetic variability in its traits, including growth habit, stem pigmentation, and pod color. Retrospectively, *L. purpureus*'s systematic crop improvement efforts received less attention from researchers. In the current study, 11 local accessions of *L. purpureus* that were collected from various locations in Arunachal Pradesh—a global biodiversity hotspot, and their morphological and biochemical characteristics were examined. The conventional procedure for analyzing nutritional and anti-nutritional components found considerable variations for each of the characters under the study. The length, width, and pod color differed significantly across the eleven genotypes examined in the study. All accessions had good nutritional content and very low anti-nutritional elements, particularly the phytic acid was extremely low (1.77–2.43 mg/100gm) in the tender pod when compared to the lablab accessions of south Indian states as well as of common leguminous vegetables. The low phytate content assumes significance for enhanced mineral bioavailability, making its immature pods the potential functional food, thus, carving the pathways for mitigating the nutritional vulnerability in developing countries. These local accessions of lablab also represent an agronomically and nutritionally important pool for *L. purpureus* improvement/breeding.

Introduction

The growing consumer awareness of the nutritional and health benefits of legumes has magnified the demand growth for them on a global scale. As legumes are the major plant protein sources, people are utilizing them more in lieu of animal protein in recent years [1]. As a result, the demand for legumes has increased. Consequently, the academic and commercial focus on the nutritional profiling of various legumes has increased, underutilized legumes are being explored for use, consumers are being informed about nutritional benefits legumes, and new strategies for promoting the consumption of hitherto popular legumes are drawn and acted upon [1–2]. Lablab, also known as Dolichos bean or Hyacinth bean (in English), is an underutilized leguminous crop belonging to the *Fabaceae* family. This legume has drawn immense research attention because of a range of nutritional benefits it offers and its resilience. This crop may strongly withstand drought stress compared to many other related species [3]. Lablab is frequently identified as grain, legume, vegetable, and even fodder possessing rich nutrients, vitamins, and protein (akin to soybean) [4]. The alternate use of lablabs by farmers as a cover crop and green manure or also as an intercrop with their main crops to ensure sustainability and conserving soil fertility [5–6]. Besides, it possesses rare pharmaceuticals which are sound therapeutic for human and animal ailments. Recently, investigations have indicated that the carbohydrate binding proteins of lablab, often resembling insulin [7], may be effective in preventing the SARS-CoV-2 and also influenza viruses, thus offering a good option for treating such diseases [8]. In the dry and semi-dry land ecosystems, smallholder farmers find this crop as a stable source of income [9]. The wider genetic diversity of lablab enables this crop to sustain a variety of climatic and environmental stresses [10–12]. Nonetheless, lablab promises to combat the "hidden hunger" – a most common problem in developing nations due to their high micronutrient content and climatic adaptation, thus helping to meet a few of the UN Sustainable Development Goals, like no poverty, zero hunger, and improved health and wellbeing [13–14] more specifically in the countries like Africa [15], Asia, and Latin America even these nations neglect research and investment priorities of lablab [16]. Hence, investigating the potential of such underutilized legumes like *L. purpureus* for increasing food and nutrition security [4], by way of broadening the genetic resource base of the crop becomes imminent. Though, there are several local accessions and landraces of the legume species which are frequently consumed as vegetables, and which also offer excellent genetic material for breeding initiatives aimed at enhancing their quality [17]. In view of this background, the present study aimed to document the local accessions of *L. purpureus* grown in Arunachal Pradesh, Northeast India and analyze its biochemical potential in an effort to investigate functional food source which was not yet documented and remained uncharacterized from nutrition points of view.

Material And Methods

Geographically, Arunachal Pradesh is the richest province in the Himalayas. Until the early 20th century, this region of India's north-east was known as "Terra Incognita," and it is still one of the least explored states (Kumar, 2021). Thus, the present study was conducted in Arunachal Pradesh, Northeast India, which lies within the Himalayan biodiversity hotspot. Using snowball sampling, which involves tapping the local networks, 43 respondents were selected, all of them being tribal women who regularly sold their surplus agricultural produce in the local market. The respondents also served as key informants and supplied details of the location of others who cultivated "*Yoksik peron*" (local name of lablab bean). Information was collected from December 2019 to January 2020 which is the peak season for harvesting the "*Yoksik peron*". We also collected distinct landraces from the fields of the growers. Indeed, studies on plant diversity are best done through participatory research to capture the perceptions of the local people. As a protocol, we also discussed with growers the free prior informed consent (FPIC) agreement and obtained their verbal consent for participating in the study and for allowing the data and samples collected from them to be used for the study.

The *L. purpureus* accessions were evaluated for health-promoting substances including carbohydrate, sugar, protein, fibre, ascorbic acid, iron, and two anti-nutritional compounds namely total phenol and phytic acid (phytates), since hyacinth bean is an under-utilized food. The detail of the methods use for estimation of nutrient profile is given as supplementary online resource (Annex-1).

Results And Discussion

Legumes (*Leguminosae*, or *Fabaceae*) are defined by their pod, or legume [18]. Within a species, pod characters are likely to be correlated with dispersal strategy and defence [19]. Pod morphology and color are important traits in common beans because they influence consumer preference for pods which are eaten as green beans for many genotypes [20]. The pod morphological characteristic of the documented accessions is depicted in Table 2.

Table 2
Pod morphological characteristics of the documented accessions

Accession code	Pod length		Pod width		No. of seed/pod	Pod colour
	Mean	Standard Deviation	Mean	Standard Deviation		
CHF-1	22.08	0.55	3.02	0.09	6	Vivid yellowish green
CHF-2	10.02	0.44	2.06	0.18	6	Vivid yellowish green
CHF-3	18.10	1.26	2.02	0.16	6	Strong yellow green
CHF-4	12.70	1.19	1.90	0.54	7	Light purplish grey
CHF-5	15.76	0.18	1.68	0.04	5	Brilliant yellowish green
CHF-6	7.28	0.32	1.76	0.09	5	Pale greenish yellow
CHF-7	14.90	0.32	4.12	0.11	5	Dark Purplish red
CHF-8	5.11	0.98	1.34	0.28	4	Light yellow green in the centre and Moderate purplish red in the margin
CHF-9	14.74	1.18	1.10	0.14	6	Light yellowish green
CHF-10	14.60	0.37	3.70	0.26	4	Vivid yellowish green
CHF-11	12.86	0.60	1.56	0.23	5	Brilliant yellowish green

The indigenous people in the study area have carefully maintained the varieties of *Yoksik peron*, which is extensively consumed locally. Based on the present survey, which also compiled information on its cultivation and usage, 11 types of the *Yoksik peron* were documented (Table 2). These differed in many parameters; for example, the width of the pod ranged from 1.34 cm to 4.12 cm and its length, from 5.11 cm to 22.08 cm (Table 2); the pods also differed in color, seed size, and shape. Of the accessions, CHF-10, CHF-4, and CHF-6 (Fig. 1) were found in abundance and also fetched higher prices than other accessions in the local market. Out of the 11 accessions (Fig. 1) documented, three were of purple pods (CHF-4,7&8). A study of Cui et al. reported that the purple lablab pods contain the natural pigments of anthocyanins and flavonols [21]. They also consolidated that compared to green pods, five kinds of anthocyanins (malvidin, delphinidin and petunidin derivatives) were found in purple pods and the major contents were delphinidin derivatives. Besides, nine kinds of polyphenol derivatives (quercetin, myricetin, kaempferol and apigenin derivatives) were also detected and the major components were quercetin and myricetin derivatives. All these compounds are having many bears several health benefits as well as various medicinal therapeutic values. Indeed, sweet white and purple lablab pods may posses' potent anti-inflammatory, powerful antioxidant as well as good cytotoxic potential [22]. This also expands the opportunity for exploration of antioxidant organic fraction and healthy foods from *Leguminosae* sp.

The indigenous people consume boiled tender pods or use the bean seeds in curries or cook the pods with fish as a side dish. Thus, in this area, the *Yoksik peron* is in greater demand as a pod, for use as a vegetable, than as a seed, unlike in southern India, where both forms are used. Seeds for the next season are traditionally harvested on new moon days, locally referred to as *Amavasya*, which is believed to protect the stored seed from pests and also prolong seed viability. Indeed, elderly women of *Adi* tribe are considered to be "walking encyclopaedia" in biocultural knowledge systems. These women play a pivotal role in retaining and transmitting biodiversity-related traditional knowledge to the next generations. The conservation of biodiversity including *Yoksik peron* occurs in three different habitats: *jhum* lands (shifting cultivation land), *Morang* forests (community managed forests), and home gardens [23]. Hosfield et al. suggested environment-specific adaptation of varieties for nutritional traits. In order to test such a hypothesis genotype to environmental interactions need to be analyzed [24].

Nutritional and antinutritional profile of the accessions

Table 3 Carbohydrate and sugar content in the Lablab accessions

Accession code	Total Carbohydrates (g/100g)	Total sugars (g/100g)	Reducing sugars (g/100g)	Non-reducing sugars (g/100g)
CHF-1	41.18 ±0.97	24.11±0.95	14.06±0.37	9.05±0.32
CHF-2	27.33 ±0.65	18.82±0.63	13.94±0.038	4.39±0.15
CHF-3	42.20 ±0.78	26.03±0.68	15.56±0.25	9.42±0.41
CHF-4	32.16 ±0.41	23.25±0.44	16.17±0.073	6.37±0.18
CHF-5	26.13 ±0.65	18.17±0.39	10.14±0.22	7.23±0.085
CHF-6	28.66 ±0.69	23.68±0.021	14.32±0.49	8.42±0.29
CHF-7	46.07 ±0.69	27.41±0.57	19.27±0.42	7.32±0.31
CHF-8	48.56 ±0.93	29.83±0.32	20.62±0.84	8.29±0.06
CHF-9	38.92 ±0.34	19.16±0.10	14.31±0.14	4.37±0.19
CHF-10	36.93 ±0.51	21.55±0.41	13.38±0.55	7.35±0.22
CHF-11	26.13 ±0.51	18.56±0.82	11.07±0.41	6.74±0.073

Carbohydrates act as an ideal source of energy and are also required for the maintenance of several metabolic processes. The carbohydrates help in regulation of blood glucose, insulin, cholesterol and triglycerides metabolism, bile acid dehydroxylation, protein glycosylation, etc. [25]. The results revealed that all the accessions from Arunachal Pradesh are quite good source of carbohydrates with carbohydrate value ranging from 26.13- 48.56 g/100g), of which the maximum was observed in CHF 8 (48.56 g/100g). Sugars are one of the important fractions of carbohydrates that helps in the stimulation of the feel-good hormone (serotonin), and are also linked to obesity, heart disease, cancer, severe PMS, dementia, and diabetes. Its limited consumption is an essential requirement for a healthy life [25]. In the present investigation, the total sugar value for the 11 accessions of Lablab exhibited a wide variation in the range of 18.17±0.39-29.83±0.32 g/100g, whereas the reducing and non-reducing sugars exhibited a variation of 10.14±0.22-20.62±0.84 g/100g and 4.37±0.19-9.42±0.41 g/100g, respectively. The sugar content in Lablab can provide sufficient energy for males and females in the range of RDA value of 36g/day for males and 25g/day for females.

Carbohydrates and proteins from legumes are major components of the human diet and have been reported to exert beneficial effects on gut health. Potential health benefits are related to both the prevention and treatment of chronic diseases, including type 2 diabetes, cardiovascular diseases, obesity, inflammatory diseases, and cancer [26]. Legumes are also a valuable source of dietary fibre (5–37%), containing significant amounts of both soluble and insoluble dietary fibre [27-29]. The monomers in legume dietary fibres include glucose, galactose, fucose, arabinose, rhamnose, xylose, and mannose. Legumes also contain significant amounts of resistant starch and oligosaccharides, mainly raffinose, which have been reported to possess prebiotic properties [27].

Table 4 Status of other nutritional parameters in Lablab accessions

Accession code	Crude Protein (g/100g)	Crude Fibre (g/100g)	Ascorbic Acid (mg/100g)	Fe (mg/100g)	Phenols (mg TAE/g)	Phytic acid (mg/100g)
CHF-1	32.31±0.19	13.47±0.22705	144.61±1.12	6.95±0.25	5.95±0.019	2.04±0.02
CHF-2	34.22±1.33	11.35±0.27623	151.77±1.04	6.3±0.04	4.88±0.04	2.11±0.08
CHF-3	28.95±1.15	14.83±0.561438	142.5±1.01	5.31±0.19	4.54±0.18	1.97±0.03
CHF-4	31.53±1.31	12.03±0.140968	150.6±0.69	7.11±0.15	8.93±0.21	2.01±0.07
CHF-5	33.01±1.19	10.97±0.346088	144.17±1.04	6.17±0.18	3.17±0.07	2.43±0.03
CHF-6	34.03±1.07	11.69±0.052686	149.8±0.59	6.34±0.20	4.34±0.18	1.77±0.06
CHF-7	27.19±0.76	15.32±0.331422	171.03±0.91	5.77±0.01	5.17±0.15	1.83±0.07
CHF-8	24.23±0.11	17.01±0.475311	153.67±1.08	7.02±0.15	5.02±0.14	1.79±0.06
CHF-9	32.03±1.39	12.98±0.3159	142.7±0.99	6.12±0.09	9.12±0.04	2.07±0.04
CHF-10	28.82±0.36	12.19±0.384577	146.6±0.93	6.17±0.19	5.17±0.21	1.99±0.02
CHF-11	35.81±1.39	11.04±0.011547	189.17±1.05	5.99±0.26	6.29±0.14	2.13±0.04

Significant differences in the protein composition of tender pods were discovered throughout the biochemical investigation. All of the accessions (24.23-35.81 g/100g) had high crude protein content, with CHF-11 having the highest value (35.81 g/100g). The Lablab pod's total protein content was higher than that of the other regularly consumed legumes, *Cicer arietinum* (20.7%), or *Vigna mungo* (23.6%), according to proximate analysis [30]. The astonishingly high level of protein in the Lablab pod accentuates its importance in surmounting the protein malnourishment among children and elders. Ascorbic acid (Vitamin C) is a reliable, reducing agent involved in collagen synthesis, bone and teeth calcification and other reactions in the body as a reducing agent [31]. Vitamin C is high in all the accessions (142.5–189.17 mg/100g). In the present investigation, the accession CHF-11 has maximum vitamin C content (189.17 mg/100g), which fulfils the daily referenced intake of vitamin C is on the level 80 mg/day as Recommended Dietary Allowances (RDA) for Indians [32]. Likewise, all the accessions of Lablab also contain significant amount of iron (Fe) which ranges from 5.31-7.02 mg/100g, the accession CHF-8 has maximum iron content (7.02 mg/100g). According to a recent study, the prevalence of anaemia among adolescents ranges from 10 to 20%, particularly in poor nations like India [33] and Lablab can contribute to overcome this situation.

Anti-nutritional contents

Phenols are the hydroxyl group-containing aromatic compounds that offer resistance to disease and pest in plants and are also the anti-herbivore feature existing in plants. These include an array of compounds like tannins, flavonols, etc. Among phenolic antioxidant compounds, especially flavonoids that alone account for approximately two third of the total dietary phenolics in plant-based food offer a captivating assurance, as they act as ROS scavengers as well as metal chelators, offering double protection [34]. However, the rest one-third of phenolics that include tannins, etc. may also act as anti-nutritional agents by displaying impaired nutritional quality, lower digestibility, and reduction in food consumption [35]. In the present study, the phenol content in the tender pods ranged from 6.34 to 18.24 mg TAE/g (Table 3). The average intake of phenols on daily basis varies from 6.987 mg [36]. Hence, the low phenol content in the 11 accessions not only offers food with promising antioxidant potential but also with low anti-nutritional properties. Indeed, phenolic bioactive compounds of plant origin are those secondary metabolites possessing desired health benefit effects [37]. Their consumption may play a role in the prevention of several chronic diseases as potent antioxidant properties, prevention of diseases induced by oxidative stress, and prevention of some specific cardiovascular (mainly high cholesterol levels, high blood pressure) and neurodegenerative diseases (such as Alzheimer's or Parkinson's, type II diabetes, cancers, urinary tract infections) [38-39]. However, the health effects of phenolic compounds are dependent on their type, quantity consumed, as well as on their bioavailability.

Phytic acid has an anti-nutritional property because of its ability to lower the bioavailability of essential minerals and to form a complex with protein [31]. In plant-based diets, phytate (myo-inositol hexakisphosphate) is the main inhibitor of iron absorption [40]. In the present study, the phytic acid content in the tender pods was found extremely low (1.77-2.43 mg/100gm) as compared to 50 accessions of south India where- its concentration is found to range from 19.3 to 22.0 mg/100g [41]. Thus, the findings suggest that distinct microenvironments may have existed within the localized collection area and that Lablab populations with distinct traits colonized these microenvironments. When compared with that of some commonly consumed legumes, *Vigna radiata* (452.80 mg/100 g) and *Vigna mungo* (718.08 mg/100 g) it was negligible [42]. The permissible range of phytate for the human diet is 0.25–0.50 g/ 100 gm [43].

Scoring and ranking of the accessions

When a significant number of fresh plant genetic materials are screened and/or a large number of attributes are evaluated, scoring techniques are frequently used [44]. The accessions were ranked from the highest to the lowest or from the best to the worst based on their nutrient and anti-nutrient traits for the purpose of placing the order of worth. In doing this, the accessions possessing the highest on the characteristic being measured and also the one that is lowest, are indicated. The highest score was assigned to the accessions with the highest nutritional component, whereas the lowest score was assigned to the accessions with the least quantity of nutritional component. Thus, there were eleven accessions to be appraised, there will be eleven ranks from 1 to 11 and the results are depicted in Table 5.

Table 5 Ranking of the accessions based on their nutrient and anti-nutrient traits

Accession Code	Total Carbohydrates	Total sugars	Reducing sugars	Non-reducing sugars	Crude Protein	Crude Fibre	Ascorbic Acid	Phenols	Fe	Phytic acid	Mean Score	Rank
CHF-1	8	8	5	10	7	8	4	8	9	5	7.2	III
CHF-2	3	3	4	2	10	3	8	5	7	3	4.8	X
CHF-3	9	9	8	11	4	9	1	4	2	8	6.5	VI
CHF-4	5	6	9	3	5	5	7	10	11	6	6.7	V
CHF-5	2	1	1	5	8	1	3	2	6	1	3.0	XI
CHF-6	4	7	7	9	9	4	6	3	8	11	6.8	IV
CHF-7	10	10	10	6	2	10	10	7	3	9	7.7	II
CHF-8	11	11	11	8	1	11	9	6	10	10	8.8	I
CHF-9	7	4	6	1	6	7	2	11	5	4	5.3	VIII
CHF-10	6	5	3	7	3	6	5	7	6	7	5.5	VII
CHF-11	2	2	2	4	11	2	11	9	4	2	4.9	IX

Table 4. reveals the elite accessions based on their nutritional and anti-nutritional traits. Of the eleven accessions, CHF-8 could be considered an elite accession as it attain a maximum weighted score (8.8) followed by CHF-7 (7.7) and CHF-1 (7.2). This denotes that CHF-1 (see Fig. 1) has high nutritional value and low anti-nutrition concentrations, thus may be the best candidate for future breeding programs for developing improved cultivars of Lablab.

Conclusion

Despite legumes being the second-most significant crop after cereals, their nutritional and functional advantages still remained inadequately comprehended. This preliminary study offers empirical evidence on the nutritional and functional advantages of local diverse accessions of lablab which are still underutilized, underexplored and remained uncharacterized from nutrition points of view in the far eastern Himalayan region i. e. Arunachal Pradesh, Northeast India. Findings established that some of the accessions documented are excellent genetic material for breeding initiatives aimed at enhancing the quality of lablab, particularly in terms of extremely low concentration of phytic acid in tender pods as compared to accessions/landraces reported to date. All the accessions collected are maintained and cultivated by low-income group of indigenous people at the household level. Increased use of Lablab would augment their demand, thereby encouraging local farmers to boost their production for diverse nutritional utilities. This would enhance the financial stability and food and nutritional security of the indigenous people in the region.

Declarations

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Formal analysis and investigation: [Siddhartha Singh, Tara Singh Mehra & Vadde Mounika]; Writing - original draft preparation: [Dileep Kumar Pandey, Siddhartha Singh, Shanatnu Kumar Dubey]; Writing - review and editing: [Dileep Kumar Pandey, Sreenath Dixit, Gajanan Sawargaonkar, Siddhartha Singh, Shanatnu Kumar Dubey, Tara Singh Mehra & Vadde Mounika]; Resources: [Dileep Kumar Pandey, Siddhartha Singh, Shanatnu Kumar Dubey, Tara Singh Mehra, Vadde Mounika, Sreenath Dixit & Gajanan Sawargaonkar]. All authors have read and agreed to the published version of the manuscript.

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Data Availability

All data generated or analyzed during this study are included in this published article.

Ethics Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Conflict of Interest The authors declare that they have no conflict of interest.

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Figures



Figure 1

Pod morphology of the accessions documented from Arunachal Pradesh, Northeast India **a.** CHF-6; **b.** CHF-9; **c.** CHF-10; **d.** CHF-11; **e.** CHF-7; **f.** CHF-3; **g.** CHF-2; **h.** CHF-8; **i.** CHF-5; **j.** CHF-4; **k.** CHF-1

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