Analysis of Mineral Content in Cluster Bean [*Cyamopsis tetragonoloba* (L.) Taub] Genotypes for Improving Nutrition and Enhancing Food Security

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Abstract: Addressing the dual challenges of food security and nutritional adequacy, this study was conducted to analyze the mineral composition of twenty cluster bean genotypes to identify those with the highest nutritional value. The evaluation of genotypes revealed significant variations in essential minerals content, including potassium, phosphorus, sodium, calcium, magnesium, iron, and zinc. The study identified several genotypes with high levels of these essential minerals, including VRCB-10 and KAU Suruchi for potassium (1.95%), IC-39983 for phosphorus (0.20%), IC-39981 for sodium (0.25%) and zinc (52.50 ppm), IC-39980 for calcium (1.60%), GP-14 for magnesium (1.69 %) and GP-12 for iron (503.50 ppm). The results of this study can be used to promote the cultivation of cluster bean genotypes that provide superior nutritional value, thereby contributing to improved food security.

Keywords: Minerals, Cluster bean, Nutrition, Legumes

Underexploited vegetables are rich in protein, vitamin A, vitamin C, potassium, calcium, thiamine, riboflavin, folate, antioxidants and dietary fibre. They are cheap, locally available and locally acceptable, hence an ideal alternative for costly off-season vegetables for maintaining the population healthy and nutritionally secure (Pradeepkumar and Divya 2023). Legumes are dicotyledonous annuals or perennials belonging to Fabaceae family and cultivated throughout the world for their nutritious pods and seeds. In developing countries like India, where much of the population falls under low-income categories, affordable and accessible plant protein sources like legumes are crucial in combating malnutrition. So, consumption of legume vegetable needs to be given attention (Aghora et al 2023).

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] [2n=14] is one of the most important underexploited leguminous vegetable belonging to the family Fabaceae. This drought-tolerant annual crop has high socioeconomic value and is primarily cultivated in arid and semi-arid regions for its tender pods and seed endospermic gum. High adaptation towards erratic rainfall, multiple industrial uses and importance in cropping system for soil enrichment properties, low input requirement, etc. have made guar one of the most significant crops for farmers in arid areas in India (Kumari et al 2020). Cluster beans offer numerous health benefits, being rich in fibre, protein, and essential nutrients. They help to lower LDL cholesterol, support heart health, and boost haemoglobin levels. Their calcium and phosphorus content strengthens bones, while their low hypoglycemic properties aid in blood sugar control, making them ideal for diabetics. Additionally, they promote foetal development, prevent birth defects, and calm nerves. Rich in vitamins A, B, K, and minerals like calcium, iron, and potassium, cluster beans also act as a natural laxative (Mall and Tripathy 2015).

Research works focused mostly on more popular vegetables like tomato, chilli, watermelon, cucumber, brinjal etc. Minor work has been done on improvement of underutilized vegetables, which form the future vegetables that provide nutritional security to rural people. (Palanisamy et al 2015). Hence, the present investigation was done to analyze the nutrient composition of various cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] genotypes, with a particular emphasis on their mineral content, aiming to improve nutrition and enhance food security.

MATERIAL AND METHODS

Experimental site: The present study was conducted at the Department of Vegetable Science, College of Agriculture, Vellayani, Thiruvananthapuram of Kerala during 2022- 2024. The experimental plot was situated at a latitude of 8.4° N and a longitude of 76.9° E, at an altitude of 29.00 m above mean sea level. The predominant soil type of the experimental site was red loam belonging to Vellayani series, with a sandy clay loam texture. The region experiences a warm, humid tropical climate.

Treatment details: Seeds of twenty genotypes of cluster bean were collected from state and national institutes,

research stations along with the released variety of Kerala Agricultural University (Table 1). Seeds of twenty genotypes of cluster bean were sown under open field conditions in a plot size of 4.50 m^2. Seeds @ 10 to 12 kg ha^{-1} were planted at a spacing of 60 cm x 30 cm. The crop was raised according to the package of practices recommendations (KAU 2016). The experiment was laid out in randomized block design with two replications comprising of twenty treatments of cluster bean.

Mineral Analysis

Potassium (%): The dried pod samples of cluster bean were digested using a diacid (HNO$_3$: HClO$_4$ in a ratio 9:4) and potassium in the digest was estimated by flame photometry method (Jackson 1973).

Phosphorus (%): The dried pod samples of cluster bean underwent diacid digestion (HNO$_3$: HClO$_4$ in a 9:4 ratio) and were estimated using the "Vanadomolybdophosphoric acid" yellow colour method (Jackson 1973). Readings were taken using a spectrophotometer at 470 nm.

Sodium (%): The sodium content in cluster bean samples was determined using the Flame Photometer method (Jaiswal 2003)after subjecting the samples to diacid (HNO$_3$: HClO$_4$ in a ratio 9:4) digestion. Sodium chloride solution was used as a standard.

Calcium (%): Calcium content was estimated using the method described by Hesse (1971). The dried pod samples

underwent diacid digestion (HNO$_3$: HClO$_4$ in a 9:4 ratio) and were assessed using the Versanate titration method.

Magnesium (%): Magnesium content was determined using the method described by Hesse (1971). The dried pod samples underwent diacid digestion (HNO$_3$: HClO$_4$ in a 9:4 ratio) and were assessed using the Versanate titration method.

Iron (ppm): The cluster bean samples were digested using a diacid (HNO$_3$: HClO$_4$ in a ratio 9:4) and analyzed for iron content using Atomic Absorption Spectrophotometer method (Jackson 1973).

Zinc (ppm): The samples of cluster beans underwent digestion using a diacid (HNO$_3$: HClO$_4$ in a 9:4 ratio) and were then analyzed for zinc content using the Atomic Absorption Spectrophotometer method (Jackson 1973).

Statistical analysis: The data was statistically analyzed in randomized block design using KAU GRAPES (Gopinath et al 2021).

RESULTS AND DISCUSSION

Potassium: The potassium content varied significantly among the different genotypes, with levels ranging from 1.00% (GP-4) to 1.95% (VRCB-10 and KAU Suruchi) (Table 1). Akcura et al (2020) also observed significant variation among ten different vegetable cluster bean genotypes for potassium and recorded a range of potassium content from 2.26 to 2.54%.

Phosphorus: Significant differences were observed in phosphorus content among the genotypes, ranging from 0.02% (IC-39981, IC11463, GP12 and VRCB 47) to 0.20% (IC-39983). Chhipa (2011) observed 0.25% phosphorus content in vegetable cluster bean. Akcura et al (2020) recorded phosphorus content ranging from 0.23 to 0.27% among ten different cluster bean genotypes.

Sodium: The genotypes exhibited significant differences for sodium content, ranging from 0.10% (IC-39984, IC-39985, GP-12 and VRCB-10) to 0.25% (IC-39981). On the contrary, Akcura et al (2020) observed sodium content ranging from 3.08 to 6.09% among different cluster bean genotypes.

Calcium: Genotypes showed a significant variation in calcium content, ranging from 0.40% (GP-14, Sikar and KAU Suruchi) to 1.60% (IC-39980). Akcura et al (2020) observed calcium content ranging from 0.68 to 0.89% in different cluster bean genotypes.

Magnesium: There was significant difference among the genotypes for magnesium content, which ranged from 0.53% (IC-39986) to 1.69% (GP-14). GP-14 was statistically on par with GP-4 and VRCB-47 (1.68%). Akcura et al (2020) recorded magnesium content ranging from 0.53 to 0.64% among ten cluster bean genotypes.

Table 1. Details of cluster bean genotypes

Source	Genotypes
NBPGR Regional Station, Jodhpur, Rajasthan	IC-39980
	IC-39981
	IC-39983
	IC-39984
	IC-39985
	IC-39986
	IC-11463
RARI Durgapur, Rajasthan	GP-4
	GP-8
	GP-12
	GP-14
	GP-19
	GP-20
ICAR- IIVR Varanasi, Uttar Pradesh	VRCB-10
	VRCB-47
	VRCB-57
	VRCB-87
Rajasthan local	Sikar
ICAR- IARI, New Delhi	Pusa Navbahar
College of Agriculture, Vellayani	KAU Suruchi

Iron: The genotypes showed significant variation in iron content, ranging from 120.25 ppm (GP-4) to 503.50 ppm (GP-12). Akcura et al (2020) reported a variation in iron content ranging from 88 ppm to 124 ppm across different genotypes of cluster bean.

Zinc: There was significant difference among the genotypes

Table 2. Mineral analysis of cluster bean genotypes

Treatments	K (%)	P (%)	Na (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)
IC-39980	1.10	0.12	0.21	**1.60**	1.02	284.00	33.25
IC-39981	1.71	0.02	**0.25**	0.65	1.02	365.00	**52.50**
Sikar	1.10	0.08	0.15	0.40	1.02	224.25	26.75
IC-39983	1.86	**0.20**	0.21	0.50	1.03	339.50	40.75
IC-39984	1.60	0.11	0.10	0.45	1.14	265.25	40.50
IC-39985	1.75	0.05	0.10	0.60	1.14	213.00	39.50
IC-39986	1.80	0.06	0.15	0.70	0.53	202.75	34.50
GP-19	1.65	0.11	0.15	1.10	1.20	208.50	33.50
GP-14	1.50	0.11	0.15	0.40	**1.69**	223.00	39.50
GP-4	1.00	0.04	0.15	0.50	1.68	120.25	36.25
PusaNavbahar	1.61	0.03	0.16	0.45	1.50	491.25	38.00
GP-20	1.36	0.04	0.15	0.60	1.50	207.00	31.00
VRCB-10	**1.95**	0.14	0.10	0.80	0.84	281.00	34.00
VRCB-57	1.41	0.04	0.15	0.70	0.73	278.50	33.50
GP-8	1.35	0.04	0.20	0.65	1.09	277.00	39.50
IC-11463	1.31	0.02	0.21	0.90	1.02	351.25	32.25
GP-12	1.65	0.02	0.10	0.80	1.14	**503.50**	48.00
VRCB-87	1.25	0.11	0.11	1.00	0.90	296.50	43.00
VRCB-47	1.50	0.02	0.15	0.50	1.68	204.00	28.00
KAU Suruchi	**1.95**	0.14	0.15	0.40	1.44	305.75	28.75
SEm (±)	0.004	0.002	0.003	0.022	0.005	0.503	0.172
CD (p=0.05)	0.011	0.006	0.009	0.066	0.014	1.489	0.509

Table 3. Minerals, deficiency disorders and nutritional significance

Minerals	Deficiency disorders	Nutritional significance	References
Potassium	Hypokalemia	Essential for maintaining fluid balance, supporting nerve transmission, muscle contraction, regulating blood pressure, and aiding in waste elimination	(Gharibzahedi and Jafari 2017)
Phosphorus	Hypophosphatemia	A key element in bones, cells, energy metabolism, and essential for DNA and ATP (as phosphate), as well as other vital functions	(Godswill et al 2020)
Sodium	Hyponatremia	Essential for maintaining proper electrolyte and fluid balance, supporting heart function, facilitating specific metabolic processes, and enabling muscle contraction and nerve transmission	(Gharibzahedi and Jafari 2017)
Calcium	Hypocalcaemia, osteoporosis, rickets	Helps to build and maintain strong bones and teeth, essential for maintaining heart, muscle, and digestive system	(Godswill et al 2020)
Magnesium	Magnesium deficiency, hypertension	Vital cellular element and the most abundant divalent cation, important for intracellular signalling, found in bones, regulates cellular functions by binding to proteins, nucleic acids, and nucleotides	(Weyh et al 2022)
Iron	Anaemia	Essential for haemoglobin formation in red blood cells, enabling oxygen transport; supports energy metabolism, electron transport within cells, and a key component of enzyme systems in tissues	(Gharibzahedi and Jafari 2017)
Zinc	Zinc deficiency	Plays a crucial role as a cofactor for over 300 enzymes, supports DNA, RNA, and protein synthesis, acts as an antioxidant, and maintains biological membrane stability, regulates hormone production	(Weyh et al 2022)

for zinc content, which ranged from 26.75 ppm (Sikar) to 52.50 ppm (IC-39981). Chhipa (2011) recorded a zinc content of 32.45 ppm in vegetable cluster bean.

CONCLUSIONS

The study highlighted several cluster bean genotypes with elevated levels of essential minerals, including VRCB-10 and KAU Suruchi for potassium (1.95%), IC-39983 for phosphorus (0.20%), IC-39981 for sodium (0.25%) and zinc (52.50 ppm), IC-39980 for calcium (1.60%), GP-14 for magnesium (1.69%), and GP-12 for iron (503.50 ppm). The results suggest that mineral-rich cluster bean genotypes could significantly contribute to improving human health by enhancing overall nutrition. As an underutilized leguminous vegetable, cluster beans are affordable and adaptable to adverse climatic conditions, making them a valuable resource for improving nutrition and enhancing food security.

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