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ASSESSMENT OF NUTRITIONAL AND QUALITY CHARACTERISTICS OF VEGETABLE SOYBEAN(*GLYCINE MAX* L. MERRILL) GENOTYPES

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ABSTRACT

The present study investigated the nutritional, antioxidant and antinutritional properties of eleven vegetable soybean genotypes and compared with the grain soybean variety (DSB34). A significant differencewas observed in all quality characteristics of selected vegetable soybean genotypes. The results of the study found that oil, energy, dietary fibre, sodium, oxalate and saponin content of Swarna Vasundhara was significantly higher than other genotypes. Protein content of AGS447(41.06g/100g), Karune (40.49g/100g) and AVSB2007 (40.17g/100g) found high. Among the genotypes, AVSB2001 found high iron, zinc, copper and total flavonoid content. Total phenolic content, phytic acid, DPPH radical scavenging activity and hydrogen peroxide scavenging activity of AVSB2013 significantly higher than other genotypes. When compared to grain type soybean, protein, fibre, oil, mineral and antioxidant content of the selected vegetable soybean genotypes was found high. Hence, increasing the cultivation, promotion and, consumption of vegetable soybean in the country could help in increasing the diversity, new product development, in addition to soymilk and food supplementation, mitigate food insecurity and to alleviate malnutrition in the country.

***Keywords*:** Vegetable soybean, Grain soybean, Antioxidants, Antinutrients, Genotypes, Nutrients

Introduction

Legumes in the diets of human beings, dates back to ancient times and constitutes one of the pillar bases of human civilization (Misquitta *et al.*, 2023; Bennetau-Pelissero, 2018). Among other early domesticated pulses are lentils (*Lens culinaris*, L. Medic.), lupine (*Lupineus albus*, L.), peanut (*Arachis hypogaea*, L.), pea (*Pisum sativum*, L.), chickpea (*Cicer arietinum*), broad bean (*Vicia Faba*, L.), common bean (*Phaseolus vulgaris*, L.), cowpea (*Vigna unguiculata*, L. Walp.), bambara groundnut (*Vigna subterranean*, L. Verdc), and soy (*Glycine max*, L. Merr) (Bennetau-Pelissero, 2018). Pulses and beans are referred as "poor man's food" and part of staple diet among the low-income population. Among the legumes used, soybean is most common and widely used, due to its high protein content (Misquitta *et al.*, 2023). Legumes have played an important role in the traditional diets of many regions throughout the world. It is difficult to think of Asia, India, South America, the Middle East, and Mexico cuisine without picturing soybeans, black beans, chickpeas, lentils, and pinto beans, respectively (Messina, 1990).

Soybean (*Glycine max* (L.) Merrill), is one of the oldest world crops, belongs toFabaceae family. It is native to Asia but currently it is widely grown in both tropical and temperate regions of the world (Zewudie and Gemede, 2024). Soybean contains more protein than oil but it is primarily used as oilseed crop in India. Grain soybean is now growing in more than 10 million hectares, primarily in Maharashtra, Madhya Pradesh and Rajasthan. However, vegetable soybean is still not very popular among the growers and consumers in India (Talukdar *et al*., 2019). Besides, emerged as the "functional food of the century" in the wake of several bio-molecules, like isoflavones, saponins, tocopherols, and protein, to stave off lifestyle diseases like diabetes, cardiovascular diseases and obesity. A wide range of conventional and next-generation soy products with novel formulations have appeared in the market to cater to the needs of the health-conscious elite (Kumar *et al.,* 2015).

In the recent years, there is an increased demand for the vegetable soybean all over the world. As a crop grown and consumed in East Asian countries, vegetable soybean has been consumed with a rising trend in the new parts of the world. Vegetable soybean is recognized as a healthy plant-based protein and is also a rich source of dietary fibre, vitamins, minerals and isoflavones. Most commonly, vegetable soybean is consumed as a snack or added to salads, soups, stews, or dips. In some countries, such as China and Taiwan, a well-developed vegetable soybean industry exists. In other countries, vegetable soybean remains as a crop in its infancy stage (Williams *et al*., 2022).

Vegetable soybean, is a group of special cultivars of soybean harvested green at the R6 stage of development, or 80% pod fill and, used as a vegetable. Vegetable soybean harvested at R6 stage have nutty, sweet, buttery, beany, and superior in flavour to grain type of soybean (Carson *et al*., 2011). Vegetable soybean quality is comprised of its agronomic characteristics, sensory attributes, and nutritional value. Vegetable soybean is a nutritious, high-value and easy-to-grow specialty crop, and an appealing product for consumers (Montri *et al*., 2006; Zhang and Kyei-Boahen, 2007). Soy foods like vegetable soybean are healthy dietary options for most consumers and are premier choices to versatile vegetarian and vegan diets (Carneiro *et al*., 2020).

In addition, vegetable soybean is rich in nutritional content than mature soybean, including higher ascorbic acid, â-carotene contents, vitamin A, C, K, B (B_1, B2 and B3) and lower amounts of indigestible oligosaccharides and anti-nutritional substances such as trypsin-inhibitors and phytates (Saldivar *et al*., 2010; Ribera *et al*., 2022; Carneiro *et al*., 2020; Shilpashree *et al*., 2021; Nair *et al*., 2023; Guo *et al*., 2022; Jankauskiene *et al*., 2021). Trypsin inhibitor is 1/3rd less in vegetable type than grain type soybean. Several factors like variety, time of harvest, and storage conditions influences the chemical composition of vegetable soybean (Wszelaki *et al*., 2005). When compared to green and snap peas, calcium iron, zinc, sodium, cupper, potassium, magnesium, phosphorus, and manganese content of vegetable soybean is higher (Djanta *et al*., 2020). It has 60% more calcium and twice the phosphorus and potassium levels than the India's most commonly consumed fresh legumes i.e., green peas (Talukdar and Shivakumar, 2016). The isoflavones content of vegetable soybean contributes to various physiological benefits such as reducing the risk of cancer, cardiovascular disease, osteoporosis, and relieving menopausal symptoms (Djanta *et al*., 2020; Li *et al*., 2022).

Vegetable soybean quality is mainly influenced by its agronomic characteristics, sensory attributes, and nutritional value. Though many studies are available on the nutritionalproperties of various vegetable soybean genotypes in different countries (Guo *et al*., 2022; Pardeshi *et al*., 2021; Hertamawati *et al*., 2021; Guo *et al*., 2020; Carrao-Panizzi *et al*., 2019; Reddy *et al*., 2019; Jadav *et al*., 2018; Xu *et al*., 2015), nutritional data on the selected vegetable soybean genotypes is not widely reported. Therefore, the present study was designed to conduct a quality traits analysis of recently developed (https://avrdc.org/seed/improved-lines/vegetable-soybean/) vegetable soybean genotypes and comparing with the grain type soybean, in order to select promising lines with suitable nutritional quality for production and cultivar development

Material and Methods

Vegetable soybean genotypes namely (AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, AGS447, Swarna Vasundhara, Karune and one grain type soybean (DSB34) were selected for the study and cultivated at an experimental farm of World Vegetable Center, ICRISAT, Patancheru, Hyderabad. All the samples were harvested at R6 stage (Growth stage when the seeds are still immature and green but are fully developed inside the pods). The total produce was deshelled and the green beans were tray dried at 60^{o}C. Dried samples was powdered and packed into airtight polyethylene bags and stored powdered for further chemical analysis. The nutritional and quality trait values are expressed as gm per 100g of edible portion.

Quality characteristics of selected vegetable soybean genotypes

- **Physicochemical properties:** pH (AOAC (1990), titratable acidity (Ranganna, 2017), Color

(Hunter Lab, 2013), chroma and hue (Pathare *et al*., 2012), total color difference (Martins and Silva, 2002), Intensity of green colour of samples was calculated as -a*/b* (Xu *et al*., 2016).

- **Determination of nutritional content:** Nutritional profiling of vegetable soybean genotypes was carried out using standard procedures with respect to moisture (AOAC, 2005), ash (AOAC, 2005), protein (AOAC, 2005), fat (AOAC, 1997), crude fiber (AOAC, 1995), carbohydrate and energy (AOAC, 1980) and dietary fibre (AOAC 985.29 – 2010).
- **Estimation of vitamin and mineral content:** Total carotenoids (Zakaria *et al*., 1979), β-carotene (Srivastava and Kumar, 1993), ascorbic acid (AOAC, 1997) and total chlorophyll content (Sadasivam and Manickam, 2018), Calcium, iron, magnesium, manganese, copper, zinc, sodium, potassium and phosphorus (AOAC, 2012) content of samples was analysed.
- **Determination of phytonutrients:** Antioxidant screening (Harbourne, 1993), flavonoid content (Zhishen *et al*., 1999), total phenols (Slinkard and Slingleton, 1997), antioxidant activity by DPPH (Tadhani *et al*., 2007; Dorman *et al*., 2004), tannins (Sadasivam and Manickam, 2018), Ferric reducing antioxidant power assay (Benzie and Strain, 1996), Hydroxyl radical scavenging activity (Guchu *et al*., 2020), Reducing power assay (Wu *et al*., 2003), oxalate content (Mishra *et al*., 2017), phytates (AOAC, 1990) and saponin content (Abidemi, 2013) of vegetable soybean samples were analysed.
- **Statistical analysis:** The obtained data were subjected to one-way analysis of variance (ANOVA, completely randomised design) and the difference between the treatments was tested using Duncan's multiple range test (DMRT) By suing IBM SPSS statistics-22. The values in tables were presented as mean ± Standard Deviation and changes in values were considered significant at the level of $p \leq 0.05$.

Results and Discussion

Physicochemical properties of vegetable soybean genotypes

Food colour is governed by the chemical, biochemical, microbial and physical changes which occur during growth, maturation, post-harvest handling and processing. Colour measurement of food products has been used as an indirect measure of other quality attributes such as flavour and contents of pigments because it is simpler, faster and correlates well with other physicochemical properties. The ΔL, Δa and Δb units are often used in food research studies to determine the uniform distribution of colours, as ΔL, Δa and Δb units are very close to human perception of colour. The colour of food ingredients is important as it has a bearing on the visual appeal of the final product (Sahin *et al*., 2011). Colour scores of samples were presented as ΔL, Δa, Δb and ΔE values and analysed using Munsell colour charts.

The colour values of vegetable soybean samples were analysed and the results were presented in Table 1. L* indicates lightness and extends from 0.0 (black) to 100.0 (white). The L* scores of the study found significant difference ($p<0.01$) among all the samples.The L values of AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, Swarna Vasundhara, Karune, AGS447 and DSB34 were 74.97, 70.45, 79.42, 75.61, 69.79, 78.62, 78.19, 78.58, 75.10, 72.17, 78.66 and, 71.55 respectively. Among the genotypes, highest L* value was found in AGS447 and lowest in AVSB 2002. The a* values represent redness (+a*value) to greenness (-a*value). A significant difference was observed in the a* values of dehydrated vegetable soybean samples. Among the selected genotypes, both AGS447 and AVSB2013 found lowest greenness values because change in green colour to brown colour was observed in these samples during drying. The b* values of all the samples were significantly different at 1% level of significance. The b* values of genotypes were ranged between 20.73 (AVSB2013)-33.00 (AVSB2007). Chroma (C*), considered the quantitative attribute of colourfulness, is used to determine the degree of difference of a hue in comparison to a grey colour with the same lightness. The higher the chroma values, the higher is the colour intensity of samples perceived by humans (Pathare *et al*., 2012). Significant ($p<0.01$) difference was observed among the chroma values of selected vegetable soybean samples.The genotype AVSB2007 found highest C* value and AVSB2013 had the lowest value.

Hue angle (h*), considered the qualitative attribute of colour. Based on this, colours have been traditionally defined as reddish, greenish, etc. A higher hue angle represents a lesser yellow character in the assays (Pathare *et al*., 2012). Hue (h*) values of Karune (74.38) was significantly ($P>0.01$) lower than other genotypes. The total colour difference (ΔE) of AVSB2009 was significantly high than other genotypes. The hue values of genotypes were ranged between 80.39 (AVSB2007)-

Table 1: Physicochemical properties of vegetable soybean

Genotype	L*	a*	b*	C*	E*	H*	Greenness index	pH	Titratable acidity (%)
AVSB2001	74.97± 0.36c	-4.89± 0.01g	30.02± 0.25h	30.42± 0.25h	80.90± 0.42f	80.74± 0.08ab	0.21± 0.00bc	6.44ef± 0.07	0.024a± 0.00
AVSB2002	70.45± 0.28a	-4.40± 0.13f	28.49± 0.33f	28.83± 0.31f	76.12± 0.38a	81.21± 0.33bc	0.22± 0.00cd	6.19a± 0.01	0.021a± 0.00
AVSB2004	79.42± 0.40e	-4.19± 0.06ef	27.71± 0.49e	28.02± 0.48e	84.22± 0.41h	81.38± 0.24bc	0.22± 0.00bcd	6.51f± 0.03	0.023a± 0.00
AVSB2006	75.61± 0.33c	-3.49± 0.2c	25.53± 0.22d	25.77± 0.25cd	79.88± 0.26e	82.23± 0.58d	0.22± 0.00bcd	6.24a± 0.01	0.027a± 0.00
AVSB2007	69.79± 0.59a	-5.47± 0.06h	33.00± 0.22	33.45± 0.23j	77.38± 0.63b	80.39± 0.17a	0.23± 0.00de	6.44ef± 0.03	0.027a± 0.00
AVSB2009	78.62± 0.16d	-3.77± 0.17d	28.06± 0.42ef	28.32± 0.39ef	83.56± 0.04h	82.33± 0.45d	0.21± 0.00bc	6.32bc± 0.03	0.024a± 0.00
AVSB2012	78.19± 0.08d	-3.99± 0.12de	24.80± 0.03c	25.12± 0.03c	82.13± 0.08g	80.85± 0.26abc	0.21± 0.00bcd	6.26ab± 0.01	0.025a± 0.00
AVSB2013	78.58± 0.12d	-1.80± 0.01b	20.73± 0.33a	20.81± 0.33a	81.29± 0.02f	85.02± 0.04e	0.04± 0.01b	6.38cde± 0.02	0.026a± 0.00
Swarna Vasundhara	75.10± 0.38c	-3.35± 0.13c	25.69± 0.07d	25.91± 0.09d	79.44± 0.38de	82.58± 0.26d	0.24± 0.00e	6.34cd± 0.00	1.023a± 1.71
Karuna	72.17± 0.22b	-4.73± 0.12g	29.88± 0.30g	30.26± 0.30g	78.25± 0.30c	80.99± 0.22abc	0.21± 0.02a	6.34cd± 0.02	0.025a± 0.00
AGS447	78.66± 0.0d	-1.49± 0.01a	21.59± 0.45b	21.65± 0.45b	81.58± 0.14fg	86.03± 0.08f	0.03± 0.00a	6.41de± 0.04	0.025a± 0.00
DSB34	71.55± 0.19b	-4.93± 0.04f	32.81± 0.07i	33.18± 0.07i	78.87± 0.17cd	81.46± 0.05fc	0.20± 0.00b	6.34cd± 0.01	0.024a± 0.00
F value	399.13	276.89	491.82	531.05	168.44	114.01	1205.89	41.94	1.01
P value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00	0.00**	0.47^{NS}

Note: The values are presented as the mean±SD of (n=3) replications. NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different (p≤0.05).

86.03 (AGS447). Greenness index (GI) of all the samples were calculated and presented in Table 1. GI was found highest in Swarna Vasundhara (0.24) and AVSB2007 line (0.23) than other samples. The green colour is under the influence of several factors. Chlorophyll content and presence of phenolic compounds at the time of harvest as well as the genetic differences cause variations in the colour components of vegetable soybeans. Physical characteristics of seeds would therefore be the first targets on which breeders should concentrate while developing improved vegetable soybean varieties, in order to enhance acceptability (Laxmibhai and Kulkarni, 2016).

The pH content of selected vegetable soybean genotypes was ranged between 6.19 (AVSB2002)- 6.62(AVSB2001). Titratable acidity gives a measure of the amount of acid present in the food. No significant difference (P<0.05) was for titratable acidity of samples (Dadzie and Orchard, 1997).

Proximate composition of the selected vegetable soybean genotypes

Table 2 presents the proximate composition of the vegetable soybean genotypesanalysed. Results revealed that moisture content of samples ranged between 6.62% and 7.76%. The ash content, which represents the total mineral content of vegetable soybean samples in the present study ranged between 5.10g/100g (AGS447) and 5.87g/100g (AVSB2001) (Table 2). Legumes are considered a major source of dietary proteins (20 to 40g/ 100g of dry matter) (FAO, 2021). Protein is an important macronutrient, primary source of nitrogen in the human diet and a functional ingredient in food formulations. It is one of the most important constituents in vegetable soybean.Among the selected genotypes, AGS447 found highest protein content (41.06g/100g dry weight) and lowest in Swarna Vasundhara (35.64g/100g Dry weight). Vegetable soybean is a good alternative diet for vegans and vegetarians due to their high protein content, quality and desirable functional properties (Yu *et al.*, 2021; Shaghaghian *et al.*, 2022). Vegetable soybean varieties with high protein content could be used in the management of protein energy malnutrition and it also helps in body building, tissue maintenance, and repair as well as strengthening the immune system (Tamangwa *et al.*, 2023). A significant difference (p<0.01) was observed in the oil content of vegetable soybean genotypes. Oil

Table 2: Proximate composition of vegetable soybean genotypes (g/100g).

Genotype	Moisture	Ash	Protein	Fat	Crude fibre	Total carbohydrate	Energy	Available carbohydrates	Dietary fibre
AVSB2001	7.07± 0.18a	5.87± 0.04e	38.90± 0.60c	20.47± 0.39cdef	7.52± 0.31ab	27.68± 0.74a	450.59± 0.25def	14.08± 1.12cde	13.58± 0.59a
AVSB2002	6.92± 0.09a	5.52± 0.09cd	37.06± 1.45b	18.12± 0.27a	7.20± 0.38ab	32.37± 1.44c	440.80± 2.11a	17.40± 0.29f	14.31± 0.14abc
AVSB2004	6.75± 0.11a	5.49± 0.08bcd	39.16± 0.40cd	18.22± 0.82a	6.82± 0.84a	30.37± 0.77b	442.17± 0.43ab	14.46± 0.70de	15.91± 0.11rf
AVSB2006	7.76± 0.25b	5.38± 0.02bc	39.61± 0.25cd	19.78± 0.61bcde	7.43± 0.05ab	27.45± 0.46a	446.35± 0.26abcd	12.12± 0.85abc	15.33± 0.38de
AVSB2007	6.64± 0.16a	5.39± 0.08bc	40.17± 0.14cde	20.79± 0.97def	7.19± 0.27abq	27.00± 0.06a	455.82± 0.46fg	11.81± 0.11ab	15.18± 0.14cde
AVSB2009	7.23± 0.38ab	5.37± 0.02b	37.37± 0.28b	18.71± 0.46ab	7.69± 0.32ab	31.30± 0.63bc	443.07± 0.35abc	16.08± 0.86ef	15.22±0. 23cde
AVSB2012	6.94± 1.03a	5.58± 0.04d	36.79± 0.36ab	19.64± 0.74bcd	7.59± 0.15ab	31.04± 0.16bc	448.12± 0.41bcde	16.91± 1.44f	14.13± 0.16ab
AVSB2013	6.70± 0.16a	5.45± 0.08bcd	39.26± 0.42cd	21.05± 0.84ef	7.68± 0.42ab	27.52± 0.85a	456.63± 0.36fg	12.75± 0.87abcd	14.77± 0.17bcd
Swarna Vasundhara	6.79± 0.03a	5.21± 0.16a	35.64± 0.24a	21.37± 0.69f	7.63± 0.97ab	30.97± 0.39bc	458.85± 0.37g	14.46± 0.36de	16.51± 0.73f
Karune	6.62± 0.10a	5.52± 0.06cd	40.49± 0.08de	18.96± 0.70ab	7.44± 0.25ab	28.39± 0.64a	446.23± 0.34abcd	13.43± 1.04bcd	14.96± 0.48bcde
AGS447	6.65± 0.04a	5.10± 0.02a	41.06± 0.64e	19.39± 0.62abc	7.49± 0.47ab	27.59± 0.75a	449.08± 0.31cde	10.90± 0.66a	16.69± 0.49f
DSB34	6.86± 0.03a	5.42± 0.02bc	36.29± 0.63ab	20.32± 0.84cdef	8.03± 0.60b	31.32± 0.26bc	453.32± 0.40efg	15.52± 0.31ef	15.79± 0.11ef
F value	2.74	19.26	17.47	7.38	1.09	16.57	8.28	19.29	18.49
P value	0.02*	0.00**	0.00**	0.00**	0.41NS	0.00**	0.00**	0.00**	0.00**

Note: The values are presented as the mean±SD of (n=3) replications. NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$)

content of selected genotypes was ranged between 18.12g/100g dry weight (AVSB2002)-21.37g/100g dry weight (Swarna Vasundhara). Various factors such as cultivar, environmental factors and geographical location influences the oil content of soybean genotypes. Soybean oil is well recognised for its high PUFA (polyunsaturated

Table 3: Vitamin content of vegetable soybean genotypes.

Genotype	Vitamin C (mg/100g)	Total carotene (µg/100g)	Beta carotene (µg/100g)	Chlorophyll content (mg/100g)
AVSB2001	30.73±3.31abc	1186.97±0.54a	296.74±0.14a	31.34±0.57b
AVSB2002	39.03±0.29d	1205.12±1.05b	301.28±0.26b	37.33±2.30c
AVSB2004	23.14±0.29a	1386.33±0.86i	346.58±0.21i	41.88±01.84e
AVSB2006	39.11±0.16d	1243.82±3.23d	310.96±0.81d	43.52±1.21f
AVSB2007	27.03±0.47abc	1240.04±0.14cd	310.01±0.35cd	43.87±2.55e
AVSB2009	23.51±2.01ab	1236.49±0.42cd	309.12±0.10cd	43.81±4.63h
AVSB2012	28.58±1.53abc	1290.90±2.25f	322.72±0.56f	35.28±0.59d
AVSB2013	22.31±1.01a	1232.63±2.21c	308.16±0.55c	35.48±0.91b
Swarna Vasundhara	31.16±2.34abc	1298.27±0.89g	324.57±0.22g	41.98±0.62g
Karune	33.53±0.35abc	1423.64±0.54j	355.91±0.14j	35.22±0.23c
AGS447	37.73±3.30bc	1323.72±0.35h	330.93±0.08h	34.44±0.12a
DSB34	31.81±1.22abc	1262.35±1.03e	315.58±0.25e	31.23±2.78c
F value	3.56	823.82	823.82	231.53
p value	0.00**	0.00**	0.00**	0.00**

Note: The values are presented as the mean±SD of (n=3) replications. NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

fatty acids) content, among which essential fatty acids (linoleic acid and alpha-linolenic acid) were reported to have cardio protective, anticancer effects andanti-obesity properties (Tamangwa *et al*., 2023).

Crude fiber quantifies the amount of indigestible cellulose, pentosans, lignins, and other similar substances found in food. Despite having little nutritional value, crude fibre provides bulk required for appropriate peristaltic activity in the intestinal tract (Aurand *et al*., 1987). No significant ($p>0.05$) difference was observed in the crude fibre content of vegetable soybean genotypes. The total carbohydrate content of samples was determined by difference method and the results were presented in Table 2. The total carbohydrate content of vegetable soybean genotypes was ranged between 27.59g/100g (AGS447) to 32.37g/100g (AVSB2002). The gross energy content of the twelve vegetable soybean varieties ranged from 440.80kcal/100g to 458.85kcal/100g. Available carbohydrate is the sum of total free sugars and total starch, which are easily digested and absorbed, and are glucogenic in human corresponding to the term 'glycaemic carbohydrates' (Longvah *et al*., 2017). Available carbohydrate content of AVSB2012 (16.91g/100g dry weight) was significantly ($p<0.01$) higher than other genotypes. Dietary fibre consists of the remnants of edible plant cells, polysaccharides, lignin, and associated substances resistant to digestion by the alimentary enzymes of humans. It includes cellulose, hemicelluloses, gums, mucilage, lignin, oligosaccharides, pectin, and other minor substances (Dai and Chau, 2017). Dietary fibre content of genotypes was ranged between 13.58g/100g (AVSB2001)-16.51g/100g (Swarna Vasundhara). Presence of fibre in food facilitates digestion, prevents constipation, and helps in the regulation of the blood sugar and lipids (Tamangwa *et al*., 2023).

Vitamin and mineral content of vegetable soybean genotypes

Total chlorophyll, total carotenoid, beta carotene and vitamin C content of vegetable soybean genotypes presented in Table 3. Significant difference ($p<0.01$) was observed in the total carotenoid content of the samples. Total carotenoid content of AVSB2004 (1386.33 μg/100g)

Table 4: Mineral content of vegetable soybean genotypes (mg/100g).

Genotype	Calcium	Iron	Copper	Zinc	Magnesium	Manganese	Potassium	Sodium	Phosphorus
AVSB2001	438.43± 1.10ef	12.00± 0.12f	0.49± 0.09b	4.97± 0.02g	201.91± 3.33cd	3.32± 0.05g	1610.41± 3.21cd	4.78± 0.16d	107.40± 4.88bc
AVSB2002	402.51± 2.27d	10.39± 0.26bc	0.77± 0.19c	3.98± 0.47de	189.97± 1.60bc	2.82± 0.28cde	1634.63± 0.57f	6.43± 0.26f	99.73± 1.05ab
AVSB2004	439.37± 1.04ef	10.59± 0.33cd	0.39± 0.00ab	4.16± 0.18de	190.28± 0.92bc	3.07± 0.09f	1609.26± 1.05c	3.71± 0.22b	113.39± 3.49c
AVSB2006	416.39± 1.05de	11.52± 0.97ef	0.40± 0.20ab	4.37± 0.39ef	193.15± 1.58c	2.98± 0.19ef	1615.46± 1.00d	5.63± 0.07e	138.10± 3.53e
AVSB2007	402.02± 0.06d	9.71± 0.08ab	0.40± 0.00ab	3.79± 0.14d	171.21± 0.63a	2.62± 0.06c	1626.81± 3.19e	5.58± 0.15e	123.74± 0.93d
AVSB2009	456.65± 5.04f	9.11± 0.74a	0.30± 0.10ab	3.37± 0.18bc	202.99± 1.57cd	2.87± 0.08def	1607.23± 2.45bc	5.40± 0.15e	107.36± 4.15bc
AVSB2012	301.49± 7.13b	9.70± 0.88ab	0.29± 0.09ab	3.26± 0.00b	171.72± 0.95a	2.11± 0.00a	1636.05± 2.09f	3.55± 0.10b	115.15± 0.48cd
AVSB2013	330.15± 5.27c	9.04± 0.13a	0.20± 0.00a	2.78± 0.10a	176.66± 1.54ab	2.38± 0.20b	1599.68± 2.12a	4.47± 0.15cd	109.03± 1.49bc
Swarna Vasundhara	252.76± 5.44a	10.84± 0.02cde	0.19± 0.00a	4.74± 0.09fg	171.35± 0.29a	2.71± 0.00cd	1647.04± 7.00g	7.65± 0.27g	98.55± 3.05ab
Karune	441.56± 0.28ef	11.35± 0.26def	0.33± 0.11ab	3.75± 0.38cd	213.69± 8.86d	3.45± 0.08g	1684.10± 1.20h	7.41± 0.03g	112.82± 6.68c
AGS447	337.46± 2.06c	10.98± 0.09cde	0.39± 0.00ab	3.04± 0.07ab	189.18± 5.02bc	2.35± 0.02b	1603.19± 6.11ab	4.11± 0.55c	111.60± 6.29c
DSB34	445.60± 0.19f	10.17± 0.03bc	0.23± 0.15a	3.10± 0.02ab	258.05± 1.79e	3.49± 0.02g	1639.71± 1.41f	2.87± 0.04a	96.52± 3.77a
F value	61.39	12.49	6.53	26.17	24.89	36.88	163.46	132.52	12.00
P value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	000**	0.00**	0.00**

Note: The values are presented as the mean±SD of (n=3) replications. NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p\leq0.05$).

Table 5: Mineral ratio of vegetable soybean genotypes.

Genotype	Na:K	Ca:P	Ca:K	Fe:Zn
AVSB2001	0.002968	4.082216	0.272247	2.414487
AVSB2002	0.003934	4.035997	0.246239	2.610553
AVSB2004	0.002305	3.874857	0.273026	2.545673
AVSB2006	0.003485	3.015134	0.257753	2.636156
AVSB2007	0.00343	3.248909	0.247122	2.562005
AVSB2009	0.00336	4.253446	0.284122	2.703264
AVSB2012	0.00217	2.618237	0.184279	2.97546
AVSB2013	0.002794	3.028066	0.206385	3.251799
Swarna Vasundhara	0.004645	2.564789	0.153463	2.28692
Karune	0.0044	3.913845	0.262193	3.026667
AGS447	0.002564	3.023835	0.210493	3.611842
DSB34	0.00175	4.61666	0.271755	3.280645
Standard (WHO, 2003)	<1	>0.5	<4	>2

was significantly higher than other genotypes. The β-carotene content of selected genotypes was ranged between 296.74 (AVSB2001)-355.91 (Karune) µg/100g dry weight). Vitamin C content of AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, Swarna Vasundhara, Karune, AGS447 and DSB34 were 31.34, 37.33, 41.88, 43.52, 43.87, 43.81, 35.28, 35.48, 41.98, 35.22, 34.44 and 31.23mg/100g, respectively (Table 3). The results of the study found highest vitamin C content in AVSB2006 (39.03mg/100g) and lowest in AVSB2013 (22.31mg/100g).

Minerals plays an important role in overall physical and mental well-being. Minerals are essential components of bones, teeth, blood, muscles, tissues, nerve cells and also helps in the maintenance of acid-base balance, response of nerves to physiological stimulation, and blood clotting (Hanif *et al*., 2006). The mineral (Calcium, magnesium, iron, zinc, sodium, manganese, phosphorus, potassium and copper) concentrations (mg/100 g) of vegetable soybean genotypes were presented in Table 4. Calcium content of vegetable soybean genotypes were ranged between 252.76mg/100 (Swarna Vasundhara) to 456.65mg/100g (AVSB2009). Among the selected vegetable soybean genotypes, AVSB 2001 found highest iron content (12.00mg/100g) and lowest in AVSB2013 (9.04mg/100g). Iron is an important micromineral used in the management of iron deficiency anaemia, as it is a vital part of red blood cells that carry and release oxygen (Etiosa *et al*., 2018). A significant difference ($p<0.01$) was observed in the copper content of vegetable soybean genotypes. Among the genotypes, AVSB2001 (0.19mg/100g) found highest copper content and lowest in Swarna Vasundhara (0.49mg/100g). Zinc content of twelve vegetable soybean genotypes were ranged between 2.78mg/100g (AVSB2013)-4.97mg/100g (AVSB2001).

Magnesium content of AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, Swarna Vasundhara, Karune, AGS447 and DSB34 were 201.91, 189.97, 190.28, 193.15, 171.21, 202.99, 171.72, 176.66, 171.35, 213.69, 189.18 and 258.05mg/100g, respectively. Manganese content of genotypes was ranged between 2.11mg/100g-3.49mg/100g (DSB34). Potassium content of Swarna Vasundhara (1647mg/100g) was significantly higher than other genotypes. Sodium is required in small amounts to help maintain normal blood pressure and normal muscle and nerve function (Zewudie and Gemede, 2024). Sodium content among the genotypes was ranged between 2.87mg/100g (DSB34)-7.65mg/100g (Swarna Vasundhara). Phosphorus content of selected vegetable soybean varieties were significantly different at 1% level of significance. Phosphorus content of DSB34 (96.52mg/100g) was low and AVSB 2006 found highest value (138.10mg/100g). Phosphorus is closely related to calcium, as their combination is important for bone mineralization and solidification (Tamangwa *et al*., 2023).

- **Mineral ratios of twelve vegetable soybean genotypes:** Mineral to mineral ratio influences the effectiveness of minerals in the diet. Some minerals either enhance or reduce the absorption of certain other nutrients in the human body (Sharma *et al*., 2014). Therefore, mineral ratios of the twelve vegetable soybean genotypes were calculated and the results were presented in Table 5.
- **Sodium to potassium ratio-**The Na/K ratio plays an important role in the diet as it reduces high blood pressure and the risk of stroke in the body. Na/K ratio of less than one is recommended in the diets to prevent and control of high blood pressure in the hypertensive patients (Zewudie and Gemede, 2024). The

Table 6: Phytonutrient composition of Vegetable soybean genotypes.

Genotype	Total phenols (mg GAE/100g)	Total flavonoid (mg RE/100g)	Tannins (mg TAE/100g)	DPPH (%)	FRAP (µg AAE/100g)	Reducing power assay (µg AAE/100g)	H2O2 scavenging activity (%)
AVSB2001	224.15±1.40b	22.99±0.52e	166.85±0.45cd	82.63±0.87de	134.36±1.15d	431.68±0.19e	22.63±0.87de
AVSB2002	230.99±0.68c	18.84±0.41ab	168.58±0.24e	80.48±1.44cd	109.83±0.69a	433.43±0.37ef	20.48±1.44cd
AVSB2004	223.55±2.53ab	17.43±0.27a	162.69±0.33a	76.51±0.68b	167.06±0.63f	448.76±0.32g	16.52±0.69b
AVSB2006	262.07±0.80g	22.58±0.82e	163.48±0.08a	78.99±2.25c	137.89±0.71d	435.49±0.11f	18.99±0.25c
AVSB2007	268.58±0.31h	22.54±1.26e	164.64±0.23b	85.36±1.08f	121.82±0.67c	470.94±0.70i	25.36±1.08f
AVSB2009	272.49±0.27f	20.46±0.31cd	166.08±0.03c	73.23±0.71a	159.41±0.10e	411.35±2.15c	13.84±0.87a
AVSB2012	254.99±0.55e	18.56±0.47ab	163.35±0.21a	75.81±1.16b	155.67±0.06e	466.45±0.20h	16.14±0.75ab
AVSB2013	288.31±0.65j	19.13±0.91bc	169.20±0.27e	88.22±0.60g	125.85±0.75c	405.79±0.09b	28.22±0.60g
Swarna Vasundhara	252.63±0.45e	18.77±0.37ab	167.49±0.41d	71.04±0.44a	110.36±1.20a	416.55±0.38d	15.34±0.14ab
Karuna	244.75±0.28d	22.38±0.35e	170.10±0.06f	79.66±0.63c	116.74±0.25b	408.49±0.06bc	19.66±0.64c
AGS447	276.47±1.21i	17.83±0.32ab	175.07±0.78g	86.55±0.66fg	136.34±0.47d	433.24±0.27ef	26.56±0.66fg
DSB34	221.38±1.00a	21.50±0.42de	163.03±0.33a	84.89±0.42ef	125.27±0.30c	383.55±0.38a	24.89±0.43ef
F value	1420.68	33.94	334.43	82.07	242.43	905.45	67.01
p value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

Note: The values are presented as the mean±SD of (n=3) replications. NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$)

sodium-potassium (Na: K) ratios of the vegetable soybean genotypes ranged from 0.0017 (DSB34) to 0.0046 (Swarna Vasundhara). Based on the result, it was observed that all the vegetable soybean genotypes including grain soybean meals would helpin the prevention hypertension and might lower blood pressure.

- **Calcium to phosphorous ratio-** The recommended Calcium/Phosphorus ratio is >0.5. If the Ca/P ratio is >1 or close to 1 in food, which facilitates good calcium/Phosphorus utilisation, important for bone formation (Keyata *et al.*, 2020). The results of the study found that all the selected genotypes found high Ca/P ratio of above 0.5, which helps in calcium absorption, particularly in growing children who require a high intake of calcium and phosphorus for bone and teeth formation.

  Which did not help calcium absorption.

- **Calcium to potassium ratio-**As shown in Table 5, the Ca: K ratio of the six soybean varieties ranged from 0.1534 (Swarna Vasundhara) to 0.2722 (AVSB2001). The Ca/K ratio is called the thyroid ratio, which play vital roles in regulating thyroid activity. Low Ca/K ratio indicates an increase thyroid expression (Keyata *et al.*, 2020). The Ca/K ratios of the all the genotypes were low compared to the standard. Hence, diets prepared from vegetable soybeans are considered good for the thyroid activity.

- **Iron to zinc ratio-** Iron and Zinc are antagonistic in nature. Iron did not impair zinc absorption up to an iron: zinc ratio of 2:1 and dose-dependent effect was observed up to a ratio of 5:1 to 10:1, and no further zinc inhibition occurred (Pérès *et al.*, 2001). The Fe/Zn ratios of the vegetable soybean genotypes ranged from 2.2869 (Swarna Vasundhara) to 3.6118 (AGS447) (Table 5). Based on the findings, it was found that the iron present in the selected genotypes didn't impair zinc absorption.

Phytonutrient composition of vegetable soybean genotypes

Free radicals produced during metabolism are harmful for the body, which cause a number of diseases and initiate chain reactions that harm proteins, lipids, nucleic acids, and cellular components both structurally and functionally. Antioxidants stop these chain reactions by eliminating the intermediates of free radicals and prevent further oxidation processes by being oxidized themselves (Sekhon *et al.*, 2017). Besides good source of nutritional components, vegetable soybean comprises several essential bioactive components having radical scavenging, anti-tumour, and anti-carcinogenic activity. Antioxidant screening of methanolic extracts of all the selected vegetable soybean genotypes identified the presence of amino acids, proteins, carbohydrates, flavonoids, phenols, tannins, alkaloids, terpenoids, saponins, glycosides, phlobatannins and steroids.

Phenolic compounds are the widely distributed secondary metabolites, contribute to the overall antioxidant activities of plant foods. Polyphenols many contribute to astringency, bitterness, flavour, odour and oxidative stability(Ghalem and Mohamed, 2021). The total phenolic content of AVSB2001, AVSB2002, AVSB2004, AVSB2006, AVSB2007, AVSB2009, AVSB2012, AVSB2013, Swarna Vasundhara, Karune, AGS447 and DSB34 were 224.15, 230.99, 223.55, 262.07, 268.58, 272.49, 254.99, 288.31, 252.63, 244.75, 276.47 and, 221.38 mg GAE/100g, respectively. Phenolic compounds exhibit a wide range of physiological properties, such as anti-microbial, antioxidant, anti-thrombotic, anti-allergenic, anti-artherogenic, anti-inflammatory, cardioprotective and vasodilatory effects (Balasundram *et al.*, 2006). Flavonoids are a largest group of more than 8000 phenolic compounds (Ghalem and Mohamed, 2021). A significant difference was observed on the total flavonoid content of vegetable soybean genotypes. Among the selected genotypes, highest total flavonoid content was found in AVSB2001 (22.99mg RE/100g) and lowest in (17.43mg RE/100g). Tannins are high molecular weight compounds which constitute the third important group of phenolics (Balasundram *et al.*, 2006). A significant difference was observed on the tannin content of selected vegetable soybean genotypes. The results of the study showed that AVSB 2013 found highest tannin content (mg TAE/100g) than other genotypes.

Radical DPPH scavenging activity of vegetable soybean genotypes were ranged between 71.04% (Swarna Vasundhara)-86.55% (AGS 447). Ferric Reducing Antioxidant Power (FRAP) assay measures the reducing potential of an antioxidant reacting with a ferric tripyridyltriazine [Fe3+-TPTZ] complex and producing a coloured ferrous tripyridyltriazine (Fe2+-TPTZ) (Benzie and Strain, 1996). The FRAP assay measures the antioxidants in the sample as a reductant in a redox-linked colorimetric reaction (Guo *et al.*, 2003). The results of the Ferric Reducing Antioxidant Power (FRAP) assay found highest FRAP activity in AVSB2004 (167.06µg AAE/100g) and lowest AVSB2002 (109.83µg AAE/100g). Genotypic variation was observed on thereducing power assay of samples. Reducing power assay of vegetable soybean genotypes were ranged between 383.55µg AAE/100g (DSB34)-466.45µg AAE/100g (AVSB2012). Reducing power is an indicative of reducing agent having the availability of atoms which can donate electron and react with free radicals and then convert them into more stable metabolites and terminate the radical chain reaction (Ganu *et al.*, 2010). Hydroxyl radicals directly denature body enzymes via oxidation of thiol (-SH) groups. The present study evaluated the hydrogen peroxide scavenging activity of methanolic extract of vegetable soybean genotypes. The results of the study found that AVSB2009 (13.84%)had lowest H_2O_2 scavenging activity and highest was observed in AVSB2013 (28.22%). A sample capable of scavenging for hydroxyl radicals in vitro is considered to be a potent antioxidant with potential effects in vivo (Guchu *et al.*, 2020).

Oxalate is an antinutrient present in a wide range of foods. A significant difference ($p<0.01$) was observed on the oxalate content of vegetable soybean genotypes. Oxalate content of genotypes was ranged between 98.63mg/100g (AVSB2001)-157.65mg/100g (Swarna Vasundhara). Saponins are naturally occurring pant secondary metabolites, have both positive and negative effects like other antinutrients such as tannins, phytates, lectins, etc. Apart from foaming and stabilising properties in food, saponins possess several biological properties such as anti-oxidant, anti-tumour, hypocholesterolaemia, hypoglycaemic, and anti-inflammatory activities (Sharma *et al.*, 2023). A significant difference ($p<0.01$) was observed on the saponin content of vegetable soybean genotypes. The results of the study found highest saponin content in Swarna Vasudhara (167.05mg/100g) and lowest in AVSB2001 (144.98mg/100g). Various factors such as origin, plant species, various environmental factors, agronomic conditions, and post-harvest treatments (processing conditions, cooking, and storage) are responsible for the type and content of saponin in food (Sharma *et al.*, 2023). Phytic acid is known as an antinutritional factor as it chelates micronutrient like calcium, magnesium, zinc and forms phytic acid-metal complex and thereby, decreases the bioavailabilityin the digestive tract (Gupta *et al.*, 2015; Kumar *et al.*, 2005). It is the principal source of phosphorus in soybean seeds. Phytic acid content of vegetable soybean genotypes were ranged from 198.74mg/100g (AVSB2001)-275.89mg/100g (AVSB2013). Phytic acid content of vegetable

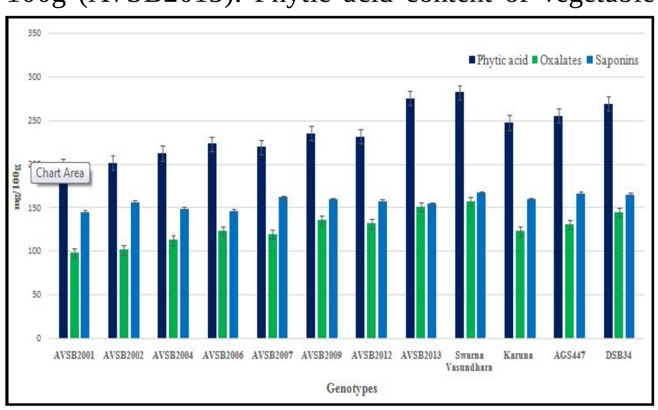

Fig. 1: Antinutrient content of vegetable soybean genotypes.

Table 7: Pearson Correlation coefficient of quality characteristics of vegetable soybean genotypes.

	Moisture	Ash	Protein	Fat	Crude fibre	l carbohyd.	Energy	ble carbohy	ietary fibre	Vitamin C	tal carote	ta caroten	rophyll con	Calcium	Iron	Copper
Moisture	1.000															
Ash	0.142	1.000														
Protein	-0.178	-0.079	1.000													
Fat	-0.101	-0.085	-0.064	1.000												
Crude fibre	0.188	-0.108	-0.265	0.490	1.000											
Total carb	0.034	0.010	-0.817	-0.489	-0.074	1.000										
Energy	-0.326	-0.217	-0.027	0.967	0.422	-0.453	1.000									
Available c	0.125	0.403	-0.797	-0.432	0.012	0.901	-0.463	1.000								
Dietary fib	-0.206	-0.896	0.144	0.042	-0.118	-0.041	0.181	-0.464	1.000							
Vitamin C	0.287	-0.172	0.131	-0.182	-0.012	-0.055	-0.227	-0.126	0.072	1.000						
Total caro	-0.439	-0.268	0.292	-0.319	-0.307	0.023	-0.169	-0.169	0.490	-0.039	1.000					
Beta carot	-0.439	-0.268	0.292	-0.319	-0.307	0.023	-0.169	-0.169	0.490	-0.039	1.000	1.000				
Chlorophy	0.320	-0.454	-0.182	-0.040	-0.268	0.182	-0.037	-0.028	0.454	-0.194	0.003	0.003	1.000			
Calcium	0.287	0.433	0.419	-0.571	-0.416	-0.127	-0.643	0.015	-0.315	-0.042	-0.003	-0.003	0.129	1.000		
Iron	0.218	0.212	0.262	-0.031	-0.176	-0.277	-0.111	-0.269	0.029	0.643	0.195	0.195	-0.300	0.194	1.000	
Copper	0.141	0.330	0.047	-0.541	-0.502	0.212	-0.579	0.289	-0.373	0.541	-0.331	-0.331	-0.158	0.447	0.302	1.000
Zinc	0.328	0.348	-0.260	0.134	-0.254	0.071	0.023	0.098	-0.088	0.263	-0.127	-0.127	0.142	0.177	0.702	0.271
Magnesiur	0.239	0.307	0.343	-0.555	-0.029	-0.057	-0.611	0.026	-0.181	0.222	0.227	0.227	-0.214	0.768	0.459	0.277
Manganes	0.194	0.434	0.205	-0.280	-0.292	-0.087	-0.345	-0.007	-0.170	0.132	0.198	0.198	0.019	0.724	0.616	0.275
Potassium	-0.265	0.077	-0.132	-0.069	0.002	0.202	-0.002	0.208	-0.069	0.290	0.500	0.500	-0.071	-0.064	0.264	-0.014
Sodium	-0.010	-0.171	-0.227	0.135	0.152	0.148	0.162	0.052	0.134	0.364	0.079	0.079	0.237	-0.016	0.260	0.053
Phosphoru	0.497	-0.047	0.532	0.050	-0.186	-0.577	-0.056	-0.510	0.021	0.158	0.039	0.039	0.345	0.277	0.150	-0.079
Total pher	-0.020	-0.605	0.213	0.410	0.564	-0.369	0.449	-0.454	0.319	-0.175	-0.148	-0.148	0.185	-0.354	-0.571	-0.548
Total flavc	0.373	0.413	0.328	0.262	0.148	-0.535	0.121	-0.284	-0.431	0.154	-0.271	-0.271	0.044	0.510	0.355	0.090
Tannins	-0.451	-0.392	0.338	0.025	0.330	-0.216	0.144	-0.347	0.293	0.378	0.133	0.133	-0.525	-0.211	0.144	0.048
DPPH	-0.313	0.052	0.725	0.217	-0.056	-0.725	0.248	-0.605	-0.162	0.091	-0.219	-0.219	-0.446	0.077	-0.021	0.201
FRAP	0.182	0.079	0.013	-0.494	-0.364	0.235	-0.508	0.193	0.121	-0.536	0.248	0.247	0.311	0.394	-0.231	-0.139
Reducing p	-0.027	0.133	0.055	-0.041	-0.508	-0.032	-0.048	0.027	-0.129	0.003	-0.064	-0.064	0.160	-0.037	-0.052	0.256
H2O2 scav	-0.377	-0.045	0.654	0.370	0.022	-0.729	0.416	-0.651	-0.064	0.097	-0.232	-0.232	-0.432	-0.080	-0.014	0.114
Phytic acic	-0.330	-0.628	-0.082	0.504	0.576	-0.105	0.614	-0.309	0.550	-0.160	0.295	0.295	0.011	-0.681	-0.263	-0.774
Oxalates	-0.144	-0.624	-0.263	0.524	0.602	0.014	0.596	-0.175	0.509	-0.302	0.154	0.154	0.233	-0.695	-0.447	-0.842
Saponins	-0.543	-0.718	-0.128	0.180	0.291	0.162	0.363	-0.099	0.554	0.073	0.250	0.250	0.117	-0.539	-0.313	-0.293

	Zinc	Magnesium	Manganese	Potassium	Sodium	Phosphorus	otal phenol	tal flavono	Tannins	DPPH	FRAP	ing power	cavenging	Phytic acid	Oxalates	Saponins
Zinc	1.000															
Magnesiur	0.165	1.000														
Manganes	0.634	0.787	1.000													
Potassium	0.205	0.187	0.335	1.000												
Sodium	0.408	0.206	0.452	0.702	1.000											
Phosphoru	-0.021	0.005	0.023	-0.127	-0.227	1.000										
Total pher	-0.709	-0.336	-0.615	-0.298	-0.110	0.240	1.000									
Total flavc	0.381	0.404	0.561	0.237	0.364	0.467	-0.041	1.000								
Tannins	-0.361	0.218	-0.103	0.058	0.186	-0.412	0.306	-0.184	1.000							
DPPH	-0.399	-0.055	-0.182	-0.332	-0.310	0.208	0.336	0.165	0.465	1.000						
FRAP	-0.110	0.165	0.050	-0.450	-0.623	0.168	-0.152	-0.305	-0.487	-0.328	1.000					
Reducing p	0.064	-0.478	-0.335	-0.101	-0.458	0.419	-0.192	-0.032	-0.507	0.068	0.225	1.000				
H2O2 scav	-0.354	-0.163	-0.233	-0.305	-0.215	0.120	0.386	0.127	0.531	0.978	-0.442	0.010	1.000			
Phytic acic	-0.384	-0.315	-0.391	0.132	0.243	-0.226	0.642	-0.311	0.449	-0.032	-0.298	-0.524	0.114	1.000		
Oxalates	-0.385	-0.459	-0.511	0.012	0.148	-0.125	0.706	-0.319	0.175	-0.199	-0.133	-0.384	-0.064	0.937	1.000	
Saponins	-0.376	-0.330	-0.451	0.320	0.351	-0.366	0.465	-0.322	0.527	-0.078	-0.359	-0.093	0.041	0.618	0.562	1.000

-1	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Note: *Significance Levels 0.05 0.01 0.005 0.001*
If correlation r => 0.94995 0.98999 0.99500 0.99896

soybean genotypes were below the WHO/FAO permissible limit of 100-400 mg/100 g, making them safe for consumption (Joseph *et al.*, 2024).

Pearson correlation coefficient of chemical composition of vegetable soybean genotypes

The results of correlation matrix of sensory and colour properties were presented in graphically presented in Table 7. The results of the study showed strong negative correlation between the total carbohydrates and protein content of vegetable soybean genotypes at 0.005 level of significance. Energy content of genotypes strongly positively correlated with fat content was observed. It was found that available carbohydrate content of genotypes was strongly negatively correlated with protein content but positively correlated with total carbohydrate content at 0.005 level of significance. The results of the study found strong negative correlation between ash content and total dietary fibre content (r= -896; p=0.00). The beta carotene content of genotypes was very strongly positively correlated with total carotenoid content of genotypes at 0.005 level of significance. It was found that calcium, copper and magnesium content of genotypes showed negative correlation with energy content of genotypes at 5%l evel of significance. Iron content of genotypes were positively correlated with vitamin C and Zinc content at 5% level of significance. Magnesium content of genotypes were positively strongly correlated with iron content at 0.005 level of significance (r= -768; p=0.003). The results of the study observed positive correction between manganese, calcium, iron, zinc and magnesium content of genotypes. Sodium content of samples were positively correlated with potassium content at 0.05 level of significance. The results of the present study observed that total phenolic content of genotypes was natively correlated with ash, zinc, manganese content. Total carbohydrate and available carbohydrate content of vegetable soybean genotypes were negative correlated with DPPH radical scavenging activity and Ferric reducing power property. Hydrogen peroxide scavenging activity of samples were positively correlated with protein (mg/100g), DPPH activity (r=0.978; p=0.00) of samples. The antinutrient, phytic acid content of genotypes were negatively correlated with ash, calcium, copper content but positively correlated with crude fibre, energy and total phenolic content. Oxalates content was negatively correlated with ash, calcium, copper, phenols and phytic acid content whereas it positively correlates with crude fibre and energy values of selected vegetable soybean genotypes. Saponin content of vegetable soybean genotypes negatively correlated with ash (r= -0.718; p=0.008) but positively correlates with phytic acid content (r=0.618; p=0.03).

Conclusion

Vegetable soybean is an important crop with high nutritional value, as it a good source of protein, lipids, dietary fibre, and many beneficial secondary metabolites in the can function as natural antioxidants. The present findings provide information on the proximate, mineral, and antinutritional composition of the vegetable soybean genotypes. The selected vegetable soybean genotypes were found to be good source of crude protein, crude fat, calcium, iron, and potassium, which could contribute a useful amount to the human diet and are low in antinutrient content. These vegetable soybean varieties can be used as functional ingredients in various food products. Hence, increasing the production and consumption of this nutrient-rich vegetable soybean genotypes will help in new product development, in addition to soymilk and food supplementation, and also alleviate malnutrition in the country.

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