J. Agr. Sci. Tech. (2022) Vol. 24(5): 1155-1170

Morphological and Biochemical Characteristics of Different Varieties of Snap Beans

A. Sheibanirad[1], M. Haghighi[1*], and L. Abbey[2]

ABSTRACT

Snap bean (*Phaseolus vulgaris* L.) is a warm-season plant, which is originated from Andes and Mesoamerica. There are wide range of morphological and biochemical characteristics in snap bean varieties. Snap bean is harvested for its green pods. The pods are a valuable source of dietary protein, essential vitamins, low-calorie carbohydrates, fiber, and minerals for human health. The evaluation of eight different snap bean varieties, namely, 'Pirbakran', 'Sunray', 'Burpees', 'Valentine', 'Dragon', 'Kentucky', 'Cherokee', and 'Id-Market' for their cultivation and nutritional value illustrated that *P. vulgaris* var. Burpees' had higher carotenoid (56%), antioxidant (16%), and phenolic compound (69%) than the popular commercial variety' Pirbakran'. Folate content was 33%, and total essential amino acids were 20.6% higher than 'Pirbakran', while the pole type 'Kentucky' showed better vegetative and pod yield indices. Additionally, 'Burpees' had the highest calcium content, which was almost 40% higher than the other varieties and two times higher in Zn compared to 'Valentine' and 'Kentucky'. In conclusion, 'Burpees' can be recommended based on its high productivity in terms of vegetative growth and pod yield, and nutraceutical values, including folate and total essential amino acids, compared to the other seven varieties.

Keywords: Endemic varieties, Folate content, Nutraceutical value, *Phaseolus vulgaris*, Pulse.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is a member of the Fabaceae family. Snap bean is the most commonly consumed legume worldwide (Duranti, 2006). The wild *P. vulgaris* has a Mesoamerican origin, and since its expansion, it has become distributed from northern Mexico to northwestern Argentina (Bellucci *et al*., 2014). Many types of *Phaseolus* exist in the web-based European Search Catalogue for plant genetic resources. The *P. vulgaris* is a domesticated gene pools that originated from Mesoamerica and the Andes (Pipan and Meglic, 2019). The morphological characteristics of *P. vulgaris* was relevant to its origin center, for example, big seed size was reported for Andean and mostly small seeds for Mesoamerican group genotypes (Pipan *et al*., 2019). Globally, there are many varieties of snap bean. Many are very similar, while others have unique textures, colors, and flavors. Snap beans can be divided into two main categories, namely, poles and bushes, although some varieties are available in both pole and bush types. The bush types produce pods for a shorter period while the pole beans need a support structure and produce pods continually (Bellucci *et al*., 2014). Snap bean grown and used in disparate regions of the world, and are a major source of protein in human diets (20–25%). It is a popular crop for its various benefits including its richness in proteins, carbohydrates, minerals, antioxidants and fiber (Aslani and Souri, 2018; Blair *et al*., 2012). Snap beans

[1] Department of Horticulture, College of Agriculture, Isfahan University of Technology, Isfahan, Islamic Republic of Iran.
[2] Department of Plant, Food, and Environment, Faculty of Agriculture, Dalhousie University, 50 Pictou Road, Truro, Nova Scotia B2N 5E3, Canada.
*Corresponding author; E-mail: mhaghighi@cc.iut.ac.ir

are a significant source of β-carotene (provitamin A), thiamin (B_1), riboflavin (B_2), niacin, pyridoxine (B_6), pantothenic acid, folic acid, ascorbic acid, and vitamin E and K (Celmeli *et al*., 2018; Prodanov *et al*., 2004). Its production and consumption is increasing, particularly in developing countries, due to its various health promoting effects including reducing the risk of cardiovascular diseases, fatness, diabetes type II, and cancer (Mojica and DeMejia, 2015).

The taste and nutrient values of vegetables are highly relevant to their chemical combination (Naiji and Souri, 2018; Balisteiro *et al*., 2013). Snap bean consumer flavor acceptance is remarkably related to sugar and organic acid contents (Vanden Langenberg *et al*., 2012). Iranian consumers prefer high sugar content and tenderness for snap bean pods (Yolmeh and Najafzadeh, 2014). Folate is involved in biosynthesis of different important metabolites including Deoxyribonucleic Acid (DNA), Ribonucleic Acid (RNA), and certain amino acids, particularly methionine biosynthesis systems (Cirdar *et al*., 2012; Wagner, 1995). Legumes have a great amount of natural folate that plays an important role in one-carbon metabolism as a co-enzyme in human. Insufficient dietary folate in the human diet was suggested as a possible risk for megaloblastic anemia and neural tube defects such as spina bifida and anencephaly (Blancquaert *et al*., 2010). The plant growth performance is mainly associated with its genetic background, environmental conditions and cropping managements (Hatamian *et al*., 2020; Ahmadi and Souri, 2019). The growth, yield and quality of bean pods are also different among varieties and climatic conditions (Farhadi *et al*., 2013).

Iran is the main snap bean producer in the Middle East, with over 6,000 ha in the production area and more than 61,000 tons of crop yield (FAO, 2016). In Iran, about 4.7% people were undernourished (FAO, 2019). Rich food crops with high nutrient values could reduce deficiencies of micronutrients. Therefore, snap beans are used as a consistence solution for global health issues (Campos-Vega *et al*., 2010). Snap beans have a high range of nutritional values required for human nutrition. Moreover, Iran has a proper situation for snap bean cultivation, such that it could be cultivated as an inexpensive source to reduce malnutrition in Iran.

There is no study available in the literature concerning comparison of Iranian varieties of snap with worldwide varieties. Grower in Iran are faced with low pod yield production and cultivation problems such as compact bush in 'Pirbakran' variety. On the other hand, foreign snap bean varieties have demonstrated high versatility and diversity for different environmental conditions. The goal of the present study was to evaluate different varieties of snap bean from different parts of the world for their yield and chemical composition compared with Iranian variety, as well as their nutritional characteristics, in order to determine more-efficient varieties for Iran.

MATERIALS AND METHODS

Data Collection

The study was conducted at the experimental greenhouse of the Isfahan University of Technology with 12 commercially important snap bean varieties in the pre-test. The characteristics of the beans are presented in Table 1. The most famous variety of Iran, namely, 'Pirbakran' and the worldwide popular variety, 'Sunray', were included in the study. The other varieties used were as follows: 'Cherokee', 'Valentine', 'Kentucky bush', 'Empress', 'Burpees', 'Dragon', 'Fine', 'Kentucky', 'Climbing-Fr', 'Id-Market', and 'Empress'. Seeds were provided from Iran (Tehran Seed Bank and Seed Savers Exchange Company) and USA Decorah, Iowa. After the pre-test analysis, seeds of eight varieties, namely, 'Pirbakran', 'Sunray', 'Cherokee', 'Valentine', 'Kentucky', 'Dragon', 'Id-Market' and 'Burpees' were chosen according to time to flower emergence, pod emergence, leaf emergence, internode length, shoot fresh weight, shoot dry weight, shoot length, pod diameter and number, yield, pods weight, tenderness and pod color as the parameters used for the pre-test selection.

Table 1. *P. vulgaris* characteristics which was used in the pre-test.

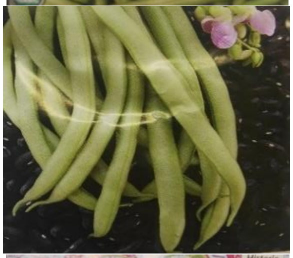
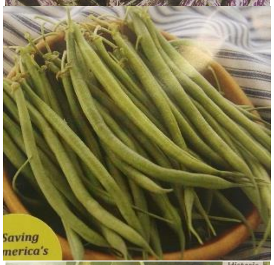
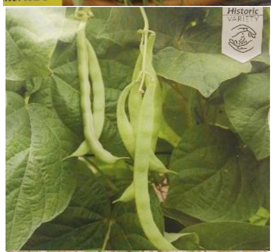
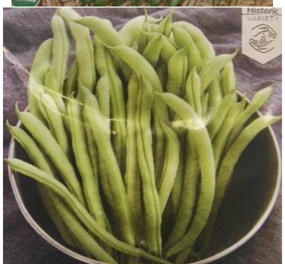
Number	Name	Characteristics known yet	Figures
1	*P. vulgaris* var. Pirbakran, 'Pirbakran'	Mostly cultivated in Isfahan, good quality, bush habit.	
2	*P. vulgaris* var. Sunray, 'Sunray'	Mostly cultivated as a foreign variety in Iran, stringless pods, bush habit.	
3	*P. vulgaris* var. Empress organic, 'Empress'	Introduced in 1979, favorable taste, long stringless pods, bush habit.	
4	*P. vulgaris* var. Black valentine, 'Valentine'	Introduced in 1897, shiny black seed in 6-inch pods, bush habit, cold temperature tolerance, dual purpose for fresh and dry bean.	
5	*P. vulgaris* var. Kentucky wonder bush, 'Kentucky bush'	Crispy stringless pods, high yield, bush habit.	
6	*P. vulgaris* var. Burpees stringless green pod, 'Burpees'	Introduced in 1894, green, 5-inch pods, stringless, bush habit.	

Table 1 is continued:

Continued Table 1.

Number	Name	Characteristics known yet	Figures
7	*P.vulgaris* var. dragon tongue, 'Dragon'	Large 6-8-inch cream colored pods with purple stripes, pods are stringless, crispy, and juicy, bush habit, high yield.	
8	*P. vulgaris* var. Fine de bangol, 'Fine'	Old French string bean, cold soil resistance, round slender pods, bush habit.	
9	*P. vulgaris* var. Kentucky wonder pole, 'Kentucky '	Known in 1864, high quality, pole habit.	
10	*P. vulgaris* var. Climbing French organic, 'Climbing-Fr'	Known from 1931, stringless pods, pole habit.	
11	*P. vulgaris* var. Ideal market, 'Id-market'	Known from 1914, very early and productive 5-inch pods, stringless, fine texture, pole habit.	
12	*P. vulgaris* var. Cherokee trail of tears, 'Cherokee'	Introduced in 1977, stringless dark green pods, pole habit.	

Experimental Method

The seeds of the eight mentioned varieties were used for hydro-priming with distilled water for 24 hours. The experimental design was a completely randomized design with three replicates and two plants per replicate. After priming, seeds were sown in plastic pots with 28.5 cm height and 23 cm diameter containing 7 kg soil and grown from September to November 2017. The soil characteristics are shown in Table 2. The distance between pots was 20 cm. Overall, 24 pots were used. During the cultivation, plants were uniformly irrigated every two days. No fertilizer or pesticide was used. The day temperature varied from 24 to 28°C, and relative humidity ranged from 75 to 85% inside the greenhouse. Pole varieties had cotton strings protector during three-month experiments. Pods were harvested from November 16th to 23rd.

In the main study, shoot fresh and dry weight, yield per bush, greenness index, total chlorophyll, carotenoid, antioxidant activity, phenolic compound, protein, sugar, starch, folate, total sulfur amino acids, total aromatic amino acids, total essential amino acids, total non-essential amino acids, total amino acids, potassium, calcium, magnesium, iron, zinc, and copper contents were measured as the characteristics for the quality analysis. The results of the pre-test are presented in Figure 1.

Table 2. Some characteristics of pot soil

EC (ds/m)	pH	N (%)	P (%)	K (%)	Zn (mg/kg)
5.3	7.6	0.08	123	414	3.8

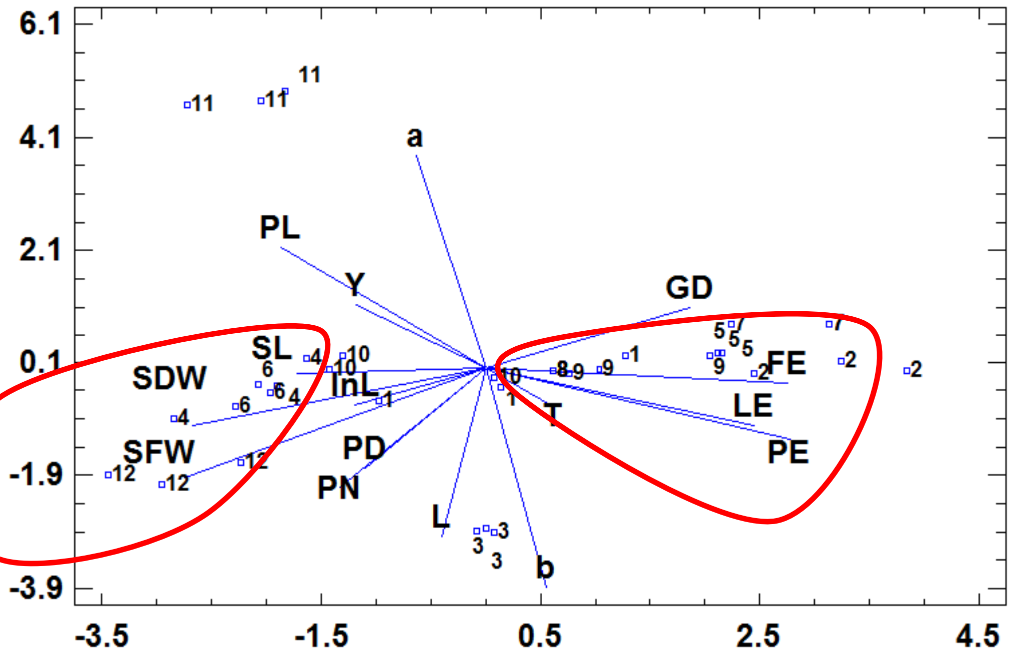


Fig 1. Pretest biplots analysis of interaction of varieties and different characteristics of snap beans. 1: Pirbakran, 2: Sunray, 3: Empress 4: Cherokee, 5: Black valentine, 6: Dragons, 7: Kentucky bush, 8: Climbing-Fr, 9: Kentucky, 10: Burpees, 11: Fine, and 12. Id-market (FE: Flower Emergence, PE: Pod Emergence, LE: Leaf Emergence, PD: Pod Dimeter, PN: Pod Number, SFW: Shoot Fresh Weight, SDW: Shoot Dry Weight, SL: Shoot Length, Y: (Yield) Pods weight, InL: Internode length, T: Tenderness, Lab: Color parameters). Eight selected varieties included: 1: Pirbakran, 2: Sunray, 4: Cherokee, 5: Black valentine, 6: Dragons, 9: Kentucky, 10: Burpees, and 12: Id- market.

Observations

The following observations were recorded in the pre-test for 14 varieties: pod number, plant yield, flower, and pod emergence defined as the most critical characteristics that influence total yield. Eight varieties (‘Sunray’, ‘Dragon’, ‘Cherokee’, ‘Burpees’, ‘Kentucky’, ‘Valentine’, and ‘Id-Market’) were selected according to the Principal Component Analysis (PCA), as in Figure 1, and used in this experiment. Nutritional and biochemical characteristics including pod number and pods weight per plant, shoot fresh and dry weights, total chlorophyll, carotenoid, antioxidant activity, phenolic compound, protein content, amino acids, nutrient elements, sugar, and starch contents of the selected eight varieties were determined.

Plant Yield and Shoot Weight

Pods were harvested when 50% had fully developed seeds (mid seed fill). Shoot fresh and dry weights were also estimated at 90 days after seed cultivation from September 1, 2017. Dry weight was calculated after 48 hours of drying in an oven (Memert, Type. Inb400, Germany) at 70°C. Pod number×Pod weight= Yield per bush was recorded.

Greenness Index

Chlorophyll meter (SPAD-502 plus, Japan) was used to measure the greenness index (SPAD value) from the adult leaves of the plant. For this purpose, from each plant, three readings were performed on three separate leaves (a total of 9 readings per replicate); then, the average was recorded.

Pod Pigments

Pods chlorophyll content was analyzed following Croft *et al*. (2020). One gram of fresh pods was mixed with 10 mL acetone solution (70%). Pods pulps removed from the solution and the obtained supernatant was utilized for total chlorophyll and carotenoid content determination by recording the absorbance at 470, 645, and 663 nm with a UV visible spectrophotometer (UV 160A-Shimadzu Corp., Kyoto, Japan). Chlorophyll a, b, total chlorophyll contents, and carotenoid were estimated as follows:

Chl a: 12.7(A663)-2.69(A645) V/W×1000
Chl b: 22.9(A645)-4.68(A663) V/W×1000
Total Chl (mg g^{-1} Dw)= (Chl a+Chl b)
Carotenoid= 100(A470)-3.27(mg Chl a)-104(mg Chl b)/227

Where, A= absorbance, V= Volume of solution, W= Weight of pod sample.

Determination of Sugar

Two-gram of each sample weighted and extracted two times in 5 ml of 80% ethanol. The solution was centrifuged at 8000×g for 10 minutes at room temperature. After that, for estimating sugar content obtained supernatant was used, and the dried pellet was used for starch analysis. Total sugar was estimated using 5 ml supernatant with a visible spectrophotometer (UV 160A-Shimadzu Corp., Kyoto, Japan) at 620 nm wavelength following Chow and Landhuasser (2004).

Starch

The dry pellet left out from total sugar extraction was suspended in 5 mL 30% perchloric acid, and the contents were mixed well with a shaker for 20 minutes. The solution was centrifuged at 10,000×g with 5 mL of distilled water for 10 minutes. The supernatant was separated, and the solution volume adjusted on 10 mL with distilled water. The mixture was incubated at 4°C temperature for 5 minutes and then transferred to a boiling water bath for 5 minutes. The mixture temperature was cooled down to room temperature, then, the starch content absorbance from the solution was recorded at 620 nm (Awais *et al*., 2020).

Extraction and Determination of Phenolic Compound

Five g of the fresh pods were extracted in 10 mL of methanol (80%). The mixtures were centrifuged for 7 minutes at 12,000×g at 4°C. The supernatant was filtered and transferred to a vial. The phenolic compound of the extracts was assessed using the Folin–Ciocalteu phenol reagent method (Singleton and Rossi, 1995). The extracts were mixed with 2 mL sodium carbonate (7.5%) and 2.5 mL Folin (1:9) and remain at 40°C for 30 minutes before recording the absorbance at 765 nm with a spectrophotometer (UV 160A-Shimadzu Corp., Kyoto, Japan). The blank sample was a mixture of water and reagents. The same procedure was repeated with different gallic acid solutions to obtain a standard curve. The phenolic compound was expressed as gallic acid equivalents in mg 100 g DW (Dry Weight) (Phuyal *et al*., 2020).

Amino Acid Profiles Determination

The High-Performance Liquid Chromatography (HPLC) (Unicam Crystal 200 HPLC system, Porto e Região, Portugal) was used for amino acids identification and quantification of pods. In an ampoule, which contained 10 mg of phenol (for protection of tyrosine) and 6 M HCl samples were hydrolyzed at 110°C for 24 hours. The mixture was diluted with 100 mL of citrate buffer and sulfur-containing amino acids. After pre-hydrolysis, oxidation with performic acids cysteine and methionine were estimated (Bradford, 1976), using HPLC equipped with MD-1510 Diode-array detector and set to 263 nm (λmax). The samples were injected with a 20 μL loop using a 7125 valve (Rheodyne, Cotati, California) onto a Purospher RP-18 column and operated at 25°C with a flow rate of 1.0 mL min^{-1} using 50 mM acetate buffer (pH 4.2) as eluent A and acetonitrile as eluent B. The amino acid content within the 100 g of pods was compared with the amino acid content in snap bean according to the culinary and technological processing method (Yu *et al*., 2002).

Antioxidant Capacity

Antioxidant activity was measured in the pods (Yang *et al*., 2013). Three g of the pods were weighted and dissolved inside 5 mL methanol stock (80%), and 1.4 mL of this solution was blended with 0.6 mL of 2, 2-Diphenyl-1-Picrylhydrazyl (DPPH) solution. The mixture was kept for 30 minutes at room temperature, then, the absorbance of the sample was recorded at 515 nm with a spectrophotometer (UV 160A-Shimadzu Corp., Kyoto, Japan) methanol stock (80%) and used as a blank.

Folate Analysis

Six g of the pod was homogenized with 20 mL of extraction buffer (0.1M phosphate buffer at pH 6.0 containing 2% sodium ascorbate and 0.1% 2-mercaptoethanol). The mixture was immediately cooled, and the pH of the extracts was adjusted to pH 4.9 with acetic acid and 3 mL of Conjugase (EC 3.4.19.9: γ-glutamyl hydrolase) was purchased from Sigma (MFCD00130719) for enzymatic hydrolyses. The sample extracts were divided into equal volumes in separate tubes, and liquid nitrogen was added to each of them. All analyses were performed using a Unicam, crystal-200 HPLC system (Porto e Região, Portugal) equipped with a quaternary gradient pump and an auto-sampler). An analytical column consisting of LiChrospher 100 RP-18, 125×4.0 mm, 5 mm (Merck, Darmstadt, Germany) with a matching guard column (4×4.0 mm, 5 mm) was tested for separation of folates (Jelena *et al*., 2003).

Protein Content

Using liquid nitrogen, the ground pods were subjected to homogenization in a 50 mM Tris buffer (pH 6.7). The solution was homogenized at 10,000×g and 4°C; the collection of the supernatant was done and kept at the temperature of 20°C. By applying the Bradford method and specifying the absorption capacity of the leaves at the wavelength of 595 nm, through employing the UV-vis spectrophotometer (UV 160A-Shimadzu Corp., Kyoto, Japan), the protein level was measured and compared with the standard curve (Bradford *et al*., 1976).

Nutrients Analysis

In order to prepare dry ash, 0.5 g of dried pods were exactly weighed before heating at 350°C for 4 hours. The obtained ash samples were digested with 10 mL 2N hydrochloric acid and then the digested mixture was heated up on an electric hot plate at 90°C until the white fume evaporated. The residue was filtered and the solution volume adjusted to 100 mL with distilled-water. The extraction was used for ICP (Inductively Coupled Plasma−Atomic Emission Spectrometer) (Perkin Elmer, Optima 7300 DV, Incheon, South Korea) nutrient determination (Salwa *et al*., 2013).

Experimental Design and Statistical Analysis

The experiment was conducted in a completely randomized design with three replications. Eight pods were used to determine each parameter. Data were analyzed statistically using Statgraphics (Centurion XVII) and Statistix (Ver.8.0). Plants were compared using Analysis Of Variance (one-way ANOVA) at P≤ 0.05. The ANOVA table is presented in Tables 3, 4, and 5.

RESULTS

There was significant difference among varieties for yield and pod weight, which was higher in pole crops compared to bush types. There was no significant difference between pole and bush beans in terms of shoot dry and fresh weight, yield, and leaf greenness. The highest shoot fresh and dry weights were recorded in 'Kentucky' and shoot dry weight was highest in 'Burpees'. Yield and greenness were highest in 'Burpees' (Table 6).

Carotenoids were higher in the bush crops compared to the pole varieties. The highest chlorophyll content, carotenoid, antioxidant activity, starch, and sugar were found in 'Burpees' compared to the other varieties. 'Kentucky' showed highest protein content. There was no considerable difference between the other seven varieties in the parameters mentioned above, except for antioxidants. 'Valentine' showed the lowest pod antioxidant content among all varieties (Table 7).

Folate was higher in 'Burpees', 'Valentine', and 'Sunray', and was lower in 'Dragon' and 'Pirbakran'. The highest total amino acid was recorded in 'Dragon', 'Valentine' and 'Burpees', and the lowest in 'Cherokee'. The amino acids in 'Dragon' and 'Burpees' were dominated by both essential and non-essential amino acids and sulfur amino acids. The high total amino acids in 'Valentine' was mainly due to essential amino acids and sulfur amino acids. Aromatic amino acids were highest in 'Pirbakran' alone compared to the other seven varieties (Table 8). There was no difference between pole and bush beans in amino acid levels (data not shown).

Potassium concentration in 'Cherokee', and calcium concentration in 'Burpees' was highest. Magnesium and iron were highest in 'Kentucky', 'Valentine', 'Burpees' and 'Dragon'. Zinc and copper were highest at 'Valentine', 'Burpees', and 'Kentucky' (Table 9).

Table 3. One-way Analysis of Variance (ANOVA) of physiological and biochemical parameters.

Source of variation	Degree of freedom	Means of squares											
		Shoot fresh weight	Shoot dry weight	Pod weights	Yield	Greenness index	Total chlorophyll	Carotenoid	Antioxidant activity	Phenolic compound	Protein content	Sugar	Starch
Varieties	7	69.354**	2.501**	12.25*	478.42**	50.131**	658.513**	3090.28**	99.023**	367.166*	69.3541**	11.2659**	190.579**
Error	16	11.624	0.357	4.36	83.25	5.185	158.680	100.45	0.6608	98.684	11.6247	0.3355	4.435
Total	23												
CV		29.65	21.76	29.8	30.57	28.21	10.97	16.14	23.08	2.35	15.18	29.65	14.09

ns: no significant, * significant at 5% and ** significant at 1%.

Table 4. One-way Analysis of Variance (ANOVA) of nutritional parameters.

Source of variation	Degree of freedom	Means of squares												
		Folate	Total sulfur amino acids	Total aromatic amino acids	Total essential amino acids	Total non-essential amino acids	Total amino acids	Potassium	Calcium	Magnesium	Ferron	Zinc	Copper
Varieties	7	200.127*	37.33994^{ns}	61.07875^{ns}	1196.203**	153.319*	1634.729*	7555.887**	272.371**	925.2992*	200.1272*	58.68247^{ns}	495.3099**
Error	16	59.55444	32.1193	41.8666	233.9638	43.87548	417.6358	275.8458	32.85905	271.5455	59.55614	32.06694	42.04923
Total	23												
CV		21.34	23.31	5.76	14.86	7.95	21.65	10.65	17.54	21.02	13.54	6.82	10.54

ns: no significant, * significant at 5% and ** significant at 1%.

Table 5. One-way Analysis Of Variance (ANOVA) of evaluated parameters for growth habit.

Source of variation	Degree of freedom	Means of squares											
		Shoot fresh weight	Shoot dry weight	Pod weights	Yield	Greenness index	Total chlorophyll	Carotenoid	Antioxidant activity	Phenolic compound	Protein content	Sugar	Starch
Growth habit	1	104.77^{ns}	1.55^{ns}	27.04*	689.83^{ns}	19.92^{ns}	208.21^{ns}	4686.66*	1.453^{ns}	22.51^{ns}	3.978^{ns}	1199.88**	0.0035^{ns}
Error	22	25.75	0.985	5.84	181.41	18.81	315.46	843.29	31.92	187.57	3.647	9.32	0.0011
Total	23												
CV		14.13	36.13	43.81	35.37	20.9	23.26	16.87	16.3	18.5	16.45	32.29	30.94

ns: No significant, * significant at 5% and ** significant at 1%.

Table 6. Growth characteristics and greenness index of eight *P. vulgaris* varieties.[a]

	Shoot fresh weight (g)	Shoot dry weight (g)	Pod weight (g pod^{-1})	Yield (g bush^{-1})	Greenness index (SPAD value)
Sunray	6.84 cd	1.6 d	6.35 bc	19.05 d	26.6 a
Pirbakran	13.65 b	2.94 bc	8.45 ab	38.03 b	18.40 cd
Dragon	12.19 bc	2.43 cd	8.49 ab	33.97 bcd	21.6 b
Valentine	10.86 bcd	2.16 cd	10.09 a	30.27 bcd	14.76 d
Burpees	7.85 d	3.52 ab	4.90 bc	19.63 cd	25.93 a
Bush	**9.88 A**	**2.55 A**	**7.65 A**	**28.19 A**	**19.57 A**
Kentucky	21.2 a	4.45 a	6.46 bc	58.21a	21.7 b
Cherokee	8.78 bcd	1.91 cd	4.07 c	24.46 bcd	17.3 c
Id-Market	12.61 bc	2.85 bc	5.85 bc	35.12 bc	19.73 bc
Pole	**14.19 A**	**3.07 A**	**5.46 B**	**39.26 A**	**21.32 A**

[a] Means were different in each column were significant at 5% of LSD. The uppercase and bold letter show the main difference between pole and bush snap beans at 5% of LSD.

Table 7. Biochemical characteristics of pods in different *P. vulgaris* varieties.[a]

	Total chlorophyll (mg 100 g Dw)	Carotenoid (mg 100 g DW)	Antioxidant activity (mg 100 g DW)	Phenolic compound (mg 100 g DW)	Protein content (mg 100 g DW)	Sugar (g 100 g DW)	Starch (g 100 g DW)
Sunray	12.54 b	23.72 d	33.17 c	29.76 bc	6.84 cd	15.11 b	0.13 ab
Pirbakran	20.517 b	45.02 c	36.78 b	14.20 c	13.65 b	16.50 ab	0.12 bc
Dragon	3.1694 b	16.94 d	36.14 b	23.68 bc	12.19 bc	13.39 bc	0.08 bc
Valentine	17.350 b	81.54 b	23.93 e	31.28 abc	10.86 bcd	10.36 c	0.09 bc
Burpees	53.058 a	104.02 a	44.17 a	46.02 a	5.85 d	19.28 a	0.16 a
Bush	**21.32 A**	**54.25 A**	**34.84 A**	**28.99 A**	**4.42 A**	**14.93 A**	**0.11 A**
Kentucky	10.92 b	28.27 cd	31.05 d	40.72 ab	21.20 a	0.4 d	0.11 bc
Cherokee	15.292 b	22.19 d	36.04 b	23.57 bc	8.78 bcd	0.25 d	0.07 c
Id-Market	19.518 b	25.69 d	35.91 b	16.67 c	12.61 bc	0.32 d	0.09 bc
Pole	**15.24 A**	**25.38 B**	**34.33 A**	**26.99 A**	**3.58 A**	**0.32 B**	**0.094 A**

[a] Means were different in each column were significant in 5% of LSD. The uppercase and bold letter showed the main difference between pole and bush snap beans in 5% of LSD.

Table 8. Folate and amino acids profile (in mg 100 g^{-1} fresh pods) of different *P. vulgaris* varieties.[a]

	Sunray	Pirbakran	Dragon	Valentine	Burpees	Kentucky	Cherokee	Id-Market
Folate (mg L^{-1})	50.42 a	33.71 c	36.55c	51.32 a	50.54 a	48.33 ab	43.09 b	41.14 b
Total Sulfur amino acids	20.06 b	23.9 b	31.39 a	24.56 ab	25.86 ab	25.23 ab	15.03 c	27.25 a
Total aromatic amino acids	8.02 d	15.48 a	9.86 d	10.72 c	9c	12.68 b	11.08 bc	13.97 b
Total essential amino acids	9.48 ab	9.24 ab	11.63 ab	12.18 a	13.14 a	10.18 b	7.62 c	10.14 b
Total non-essential amino acids	77.81 c	82.88 b	92.12 a	88.91 b	91.28 a	87.23 b	71.88 c	84.01 b
Total amino acids	115.37b	131.5 ab	145 a	136.37 a	139.78 a	135.32 ab	105.61 b	135.37 ab

[a] Means were different in each row were significant in 5% of LSD.

Table 9. Selected nutrient elements of pods in different *P. vulgaris* varieties.[a]

	K (kg DW^{-1})	Ca (kg DW^{-1})	Mg (kg DW^{-1})	Fe (kg DW^{-1})	Zn (kg DW^{-1})	Cu (kg DW^{-1})
Sunray	12.71 bc	5.23 c	12.72 b	0.582 ab	0.346 b	0.043 c
Pirbakran	11.002 c	7.65 bc	11.82 b	0.266 b	0.22 b	0.173 b
Dragon	14.63 b	9.08 b	19.7 a	0.728 a	0.315 b	0.193 b
Valentine	10.94 c	6.06 c	15.11 ab	0.72 a	0.736 a	0.21 a
Burpees	7.0.29 d	15.33 a	19.93 a	0.654 a	0.775 a	0.351 a
Kentucky	15.41 b	8.3 b	21.96 a	0.452 ab	0.87 a	0.181 ab
Cherokee	20.39 a	5.84 c	11.72 b	0.334 b	0.453 b	0.144 b
Id-Market	7.37 d	5.38 c	10.8 b	0.245 b	0.207 b	0.119 b

[a] In each column, means with at least one common letter are not statistically different at 5% of LSD test.

In ‘Id-market’ and ‘Pirbakran’ varieties shoot fresh weight, yield, protein content, magnesium, potassium, and aromatic amino acids content parameters were related together. ‘Dragon’ and ‘Valentine’ varieties showed higher biochemical characteristics such as: zinc, folate, essential amino acids, antioxidants, and phenolic compounds. The ‘Kentucky’ shoot fresh weight was higher than other evaluated varieties. ‘Cherokee’, ‘Burpees’, and ‘Sunray’ were out of assessment parameters. Particularly, ‘Burpees’ demonstrated better biochemical characteristics such as nutrient elements, amino acids, antioxidant activity, phenolic compound and folate content (Figure 2).

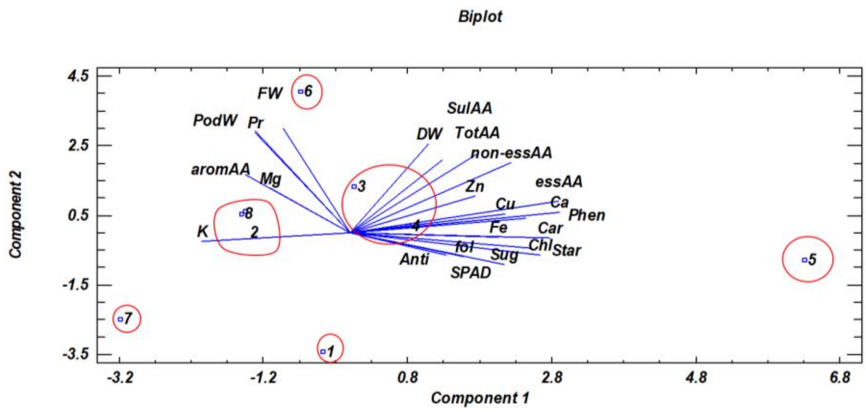


Figure 2. Biplot analysis of all the evaluated parameters in eight snap bean varieties. 1: ‘Sunray’, 2: ‘Pribakran’, 3: ‘Dragon’, 4: ‘Valentine’, 5: ‘Burpees’, 6: ‘Kentucky’, 7: ‘Cherokee’, 8: ‘Id-market’. Shoot Fresh (FW) and Dry Weight (DW), mean Pod Weight per bush (Pod W), greenness index (SPAD), total Chlorophyll (Chl), carotenoid (car), Antioxidant activity (Anti), Phenolic compound (Phen), Protein content (Pr), Sugar (Sug), Starch (Star), folate (fol), total Sulfur Amino Acids (Sul AA), total aromatic Amino Acids (arom AA), total essential Amino Acids (ess AA), total non-essential Amino Acids (non-ess AA), total Amino Acids (tot AA), K, Ca, Mg Fe, Zn and Cu.

All evaluated varieties were rich in potassium, magnesium, and total amino acids. Moreover, ‘Burpees’ variety was richer for calcium, and carotenoid content compared with other varieties. Furthermore, folate and phenolic compound content were considerable in snap bean pods, which were not affected by varieties (Figure 3).

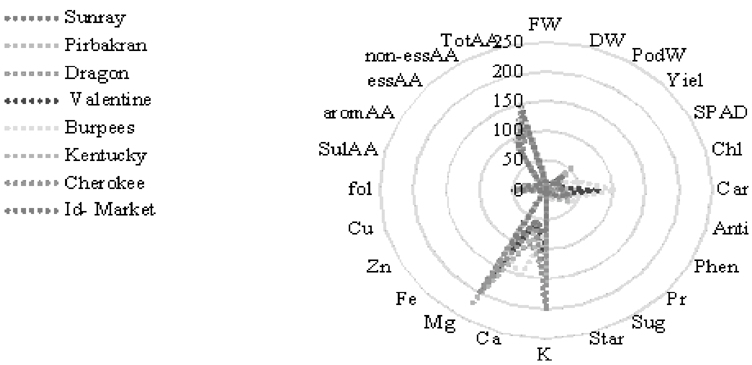


Figure 3. Spider graph of a comparison between varieties and growth, yield and quality components. Shoot Fresh (FW) and Dry Weight (DW), mean Pod Weight (Pod W), yield per bush (Yield), greenness index (SPAD), total Chlorophyll (Chl), carotenoid (car), Antioxidant activity (Anti), Phenolic compound (Phen), Protein content (Pr), Sugar (Sug), Starch (Star), folate (fol), total Sulfur Amino Acids (Sul AA), total aromatic Amino Acids (arom AA), total essential Amino Acids (ess AA), total non-essential Amino Acids (non-ess AA), total Amino Acids (tot AA), K, Ca, Mg Fe, Zn and Cu.

DISCUSSION

The results revealed that the vegetative growth parameters varied amongst the different snap bean varieties. Vegetative growth is generally associated with yield and quality production in agricultural crops and within the varieties (Souri and Hatamian, 2019; Tohidloo *et al*., 2018). Increased vegetative growth among the varieties can be ascribed to the role of their genetic differentiation, which may allow higher plant capacity to uptake more nutrients from the soil, higher photosynthetic surfaces and, therefore, better crop performance (Saleh *et al*., 2018). In the present study, 'Kentucky', as a pole variety and 'Burpees' as a bush variety, showed the highest shoot fresh and dry weight and also higher pod yield. Based on the grower cultivation condition and their purpose, 'Burpees' and 'Kentucky' varieties were preferred. Similar to the present study, previous researches indicated that growth and productivity of snap bean were affected by genetic (Arumugam *et al*., 2010) as well as by environmental factors and fertilization practices (Souri *et al*., 2018; Souri and Aslani, 2018). Leaf greenness index is a sign of leaf chlorophyll, which is also related to photosynthesis. Higher leaf chlorophyll content is explained with high photosynthetic capacity (Goncalves *et al*., 2004). In variety 'Burpees', maximum greenness index was observed, and it might be relevant to its genetic. The high greenness index and high biochemical content like total amino acids, folate, sugar and antioxidant activity in 'Burpees' might be related to its genetic potential and photosynthetic ability. Altogether, varieties of snap bean differ in leaf greenness, but the yield efficiency could be the same; this is, probably, related to genetic differences (Hefni *et al*., 2010). Moreover, Kikas and Libek (2005) showed that high-quality production of yield in different varieties was influenced by photosynthesis. Carotenoids comprise a class of natural lipid-soluble pigments that are found in many vegetables, including snap bean. They are a class of naturally occurring lipophilic pigments, and about 50 of them occur in foods with plant origin (Kalt, 2005). High carotenoids were associated with a decrease in the incidence of many chronic diseases in humans (Zhang *et al*., 2014). A study in Canada showed that total carotenoid content of bean varies among different varieties. Furthermore, it has been reported that about 2 kg snap bean was used in a year by each person. Throughout, the high consumption rate, it is important to choose the most proper variety with higher nutrition value (Djordjevic *et al*., 2011). For this purpose, variety 'Burpees' with higher carotenoid, antioxidant activity, and the phenolic compound is preferred over the other seven evaluated varieties. Bioactive compounds, like polyphenols in beans include flavonoids, phenolic acids, and procyanidins, which perform as free radical scavengers, reducing agents and metal chelators and possess hypocholesterolemia, antiatherogenic, anticarcinogenic and hypoglycemic characteristics (Balisteiro *et al*., 2013). Polyphenolics exist in low amounts in plant tissue (Russell *et al*., 2009). The results demonstrated that the variety 'Burpees' has the potential to provide more health benefits compared to the other varieties. Antioxidant and phenolic compounds are reduced after cooking (Beebe *et al*., 2001; Bybordi, and Malakouti 2007), and as such, it is better to use richer variety like 'Burpees' to obtain more of these essential secondary metabolites for human health benefit. Green beans have a considerably low amount of carbohydrates and fiber compared to ripen beans and, therefore, nutritionists encourage the consumption of fresh beans to reduce calories (El-Sherbeny *et al*., 2012). Variety 'Cherokee' showed the least amount of sugar and starch contents, while variety 'Burpees' had the highest amount of sugar and starch contents compared to the other varieties. Furthermore, because of the high sugar content in 'Burpees', it might have a better taste among the different varieties, which can improve its acceptability and marketing as a newly introduced variety (Beebe *et al*., 2001). This study confirmed that fresh 'Burpees' snap beans are a valuable source of folate. Hence, information regarding the effects of variety on folate content could be helpful in enhancing dietary folate intake. The cereal is a major source of phenolic acids-antioxidants, fibers and minerals in human diet, but they are poor in amino acids content (Laddomada *et al*., 2015). Although beans are not known to be rich in sulfuric amino acids (Haghighi *et al*., 2020), it was found to be considerably high in variety 'Dragon', and it could be considered as a positive feature for this variety. Essential amino acids are those amino acids that cannot be produced naturally in the human body, and it should be taken from foods (Haghighi *et al*., 2020). However, variety 'Burpees' seemed to have high essential amino acids compared to the others.

CONCLUSIONS

Among the evaluated varieties, 'Burpees' showed the highest nutraceutical values based on its high carotenoid, antioxidant activity, phenolic compound, folate and essential amino acids. On the other hand, variety 'Kentucky', a pole variety, showed better vegetative growth and yield. Besides, 'Burpees', 'Valentine' and 'Dragon' showed high carotenoid and amino acids, while 'Valentine' had the lowest antioxidant. Thus, variety 'Burpees' with an average yield and higher antioxidant, phenolic compound, folate, and total essential amino acids is recommended for further studies and adoption as a new crop in Iran.

REFERENCES

1. Ahmadi, M. and Souri, M. K. 2019. Nutrient Uptake, Proline Content and Antioxidant Enzymes Activity of Pepper (*Capsicum annuum* L.) under Higher Electrical Conductivity of Nutrient Solution Created by Nitrate or Chloride Salts of Potassium and Calcium. *Acta Sci. Polo. Hort. Cultus*, **18(5):**113-122
2. Arumugam, R., Rajasekaran, S. and Nagarajan, S. M. 2010. Response of Arbuscular Mycorrhizal Fungi and Rhizobium Inoculation on Growth and Chlorophyll Content of *Vigna unguiculata* (L) Walp Var. Pusa 151. *J. Appl. Sci. Environ. Manag.,* **14:** 113-115.
3. Bybordi, A. and Malakouti, M. J. 2007. Effects of Zinc Fertilizer on the Yield and Quality of Two Winter Varieties of Canola. Zinc Crops. *Inter. Cong. Improv. Crop Produc. Human Health*, Istanbul, Turkey.
4. Aslani, M., and Souri, M. K. 2018. Growth and Quality of Green Bean (*Phaseolus vulgaris* L.) under Foliar Application of Organic Chelate Fertilizers. *Open Agric*., **3:** 146–154.
5. Awais, M., Ashraf, J., Wang, L., Liu, l., Yang, X., Tong, L. T., Zhou, X. and Zhou, S. 2020. Effect of Controlled Hydrothermal Treatments on Mung Bean Starch Structure and Its Relationship with Digestibility. *Foods*, **9(5):** 664
6. Balisteiro, D. M., Rombaldi, C. and Genovese, M. I. 2013. Protein, Isoflavones, Trypsin Inhibitory and *in Vitro* Antioxidant Capacities: Comparison among Conventionally and Organically Grown Soybeans. *Food Res. Inter.,* **51:** 8-14.
7. Beebe, S., Rengifo, J., Gaitan, E., Duque, M. C. and Tohme, J. 2001. Diversity and Origin of Andean Landraces of Common Bean. *Crop Sci.,* **41:** 854-862.
8. Bellucci, E., Bitocchi, E., Rau, D., Rodriguez, M., Biagetti, E., Giardini, A., Attene, G., Nanni, L. and Papa, R. 2014. Genomics of Origin, Domestication and Evolution of *Phaseolus vulgaris*. In: "*Genomics of Plant Genetic Resources"*, (Eds.): Tuberosa, R., Graner, A., and Frison, E. Springer, Netherlands, PP. 483-507.
9. Blair, M. W., Soler, A. and Cortes, A. J. 2012. Diversification and Population Structure in Common Beans (*Phaseolus vulgaris* L.). *Plos One*., **7:** 49488.
10. Blancquaert, D. S., Storozhenko, K., Loizeau, H., De Steur, V., De Brouwer, J., Viaene, J., Ravanel, S., Rebeille, F., Lambert, W. and Van Der Straeten, D. 2010. Folates and Folic Acid: From Fundamental Research toward Sustainable Health. *Crit. Rev. Plant Sci*., **29:** 14-35.

11. Bradford, M. 1976. A Rapid and Sensitive Method for the Quantitation of Microgram Quantities of Protein Utilizing the Principle of Protein-Dye Binding. *Anal. Biochem*., **72:** 248-254.
12. Campos-Vega, R., Loarca-Piña, G. and Oomah, B. D. 2010. Minor Components of Pulses and Their Potential Impact on Human Health. *Food Res. Int.,* **43:** 461-482.
13. Celmeli, T., Sari, H., Canci, H., Sari, D., Adak, A., Eker, T. and Toker, C. 20118. The Nutritional Content of Common Bean (*Phaseolus vulgaris* L.) Landraces in Comparison to Modern Varieties. *Agron*., 8: 166.
14. Chow, P. S. and Landhäusser, S. M. 2004. A Method for Routine Measurements of Total Sugar and Starch Content in Woody Plant Tissues. *Tree Physiol.,* **24:** 1129-1136.
15. Cirdar, K. S., Yang, T. P., Berry, R. J. and Bailey, L. B. 2012. Folate and DNA Methylation: A Review of Molecular Mechanisms and the Evidence for Folate's Role. *Adva. Nutr.*, **3:** 21-38.
16. Croft, H., Chen, J. M., Wang, R., Mo, G., Luo, S., Luo, X., He, L., Gonsamo, A., Arabian, J., Zhang, Y., Simic-Milas, A., Noland, T. L., He, Y., Homolová, L., Malenovský, Z., Yi, Q., Beringer, J., Amiri, R., Hutley, L., Arellano, P., Stahl, C. and Bonal. D. 2020. The Global Distribution of Leaf Chlorophyll Content. *Remote Sens. Environ.,* **236:** 1-15.
17. Djordjevic, T. M., Siler-Marinkovic, S. S. and Dimitrijevic-Brankovic, S. I. 2011. Antioxidant Activity and Total Phenolic Content in Some Cereals and Legumes. *Inter. J. Food Prop.,* **14:** 175-184.
18. Duranti, M. 2006. Grain Legume Proteins and Nutraceutical Properties. *Fitoterapia.*, **77:** 67–82.
19. El-Sherbeny, S. F., Hendawy, A. A., Youssef, N. Y. and Naguib, M. S. H. 2012. Response of Turnip (*Brassica rapa*) Plants to Minerals or Organic Fertilizer Treatments. *J. Appl. Scie. Res*., **8:** 628- 634.
20. Farhadi, N., Souri, M. K. and Alirezalu, A. 2013. Effect of Sowing Dates on Quantity and Quality of Castor Bean (*Ricinus communis* L.) under Semi-Arid Condition in Iran. *Zeitschrift fur Arznei-und Gewurzpflanzen*, **18(2):** 72-77.
21. FAO. 2016. *Food Security Statistics*. Rome, Italy. Online Available: http://www.fao.org/3/a-i6437e.pdf [2016].
22. FAO. 2019. *Food Security Statistics*. Rome, Italy. Online Available: http://www.fao.org/faostat/en/#country/102.
23. Goncalves, B., Landbo, A. K., Knudsen, D., Silva, A. P., Moutinho-Pereira, J., Rosa, E. and Meyer, A. S. 2004. Effect of Ripeness and Postharvest Storage on the Phenolic Profiles of Cherries (*Prunus savium* L.). *J. Agric. Food. Chem.,* **52:** 523-530.
24. Haghighi, M., Saadat, S. and Abbey, L. 2020. Effect of Exogenous Amino Acids Application on Growth and Nutritional Value of Cabbage under Drought Stress. *Sci. Hortic*., **272:** 109561.
25. Hatamian, M., Rezaei Nejad, A., Kafi, M., Souri, M. K. and Shahbazi, K. 2020. Interaction of Lead and Cadmium on Growth and Leaf Morphophysiological Characteristics of European Hackberry (*Celtis australis*) Seedlings. *Chem. Biol. Tech. Agri*., **7(1):** 1-8.
26. Hefni, M., Ohrvik, V., Tabekha, M. and Witthgoft, C. 2010. Folate Content in Foods Commonly Consumed in Egypt. *Food Chem.*, **121:** 540-545.
27. Jelena, J., Cornelia, W., Anders, G. and Ulla, S. 2003. HPLC Determination of Folates in Raw and Processed Beetroots. *Food Chem.,* **80:** 579-588.
28. Kalt, W. 2005. Effects of Production and Processing Factors on Major Fruit and Vegetable Antioxidants. *J. Food. Sci*., **70:** 11-19.
29. Kikas, A. and Libek, A. 2005. Influence of Temperature Sums on Growth and Fruit Mass and Yield of Strawberry. *Europ. J. Hortic. Sci.,* **70:** 85-88.
30. Koutsika, S. M. and Traka, M. E. 2008. *Snap Bean*. Springer, New York.
31. Laddomada B., Caretto S., Mita G. 2015. Wheat Bran Phenolic Acids: Bioavailability and Stability in Whole Wheat-Based Foods. *Molecules*, **20:** 15666-15685.
32. Mojica, L. and DeMejia. E. G. 2015. Characterization and comparison of Protein and Peptide Profiles and Their Biological Activities of Improved Common Bean Cultivars (*Phaseolus vulgaris* L.) from Mexico and Brazil. *Plant Foods Hum. Nutr.,* **70:** 105-112.
33. Naiji, M. and Souri, M. K. 2018. Nutritional Value and Mineral Concentrations of Sweet Basil under Organic Compared to Chemical Fertilization, *J. Hortorum. Cultus*., **17:** 167-175.

34. Pipan, B. and Meglic, V. 2019. Diversification and Genetic Structure of the Western-to-Eastern Progression of European *Phaseolus vulgaris* L. germplasm. *BMC Plant Biol*., **19:** 422.
35. Pipan, B., Sinkovic, E., and and Meglic, V. 2019. Morphological Seed Characterization of Common (Phaseolus vulgaris L.) and Runner (Phaseolus coccineus L.) Bean Germplasm: A Slovenian Gene Bank Example. *BioMed. Res. Inter*., Volume 2019, Article ID 6376948, 13 PP.
36. Phuyal, N., Jha, P. K., Raturi, P. P. and Rajabhandary, S. 2020. Total Phenolic, Flavonoid Contents, and Antioxidant Activities of Fruit, Seed, and Bark Extracts of *Zanthoxylum armatum* DC. *Sci.,* Volume 2020, Article ID 8780704, 7 PP.
37. Prodanov, M., Sierra, I. and Vidal-Valverde, C. 2004. Influence of Soaking and Cooking on the Thiamin, Riboflavin and Niacin Contents of Legumes. *Food Chem.,* **84:** 271-277.
38. Russell, W. R., Labat, A., Scobbie, L., Duncan, G. J. and Duthie, G. G. 2009. Phenolic Acid Content of Fruits Commonly Consumed and Locally Produced in Scotland. *Food Chem*., **115:** 100-104.
39. Saleh, S., Liu, G., Liu, M., Ji, Y., He, H. and Gruda, N. 2018. Effect of Irrigation on Growth, Yield, and Chemical Composition of Two Green Bean Cultivars. *Hortic.,* **4:** 1-10.
40. Salwa, M., Hanan, L. and Nora, M. 2013. Physiological and Biochemical Responses of Two Cultivars of *Phaseolus vulgaris* L. to Application of Organic Fertilizers and Nile Compost in Sandy Soil. *Am. J. of Exp. Agric.,* **3:** 698-717.
41. Singleton, V. and Rossi, J. 1995. Colorimetry of Total Phenolics with Phosphomolybdic–Posphotungstic Acid Reagents. *Am. J. Enol. Vitic*., **16:** 144-158.
42. Souri, M. K. and Aslani, M. 2018. Beneficial Effects of Foliar Application of Organic Chelate Fertilizers on French Bean Production under Field Conditions in a Calcareous Soil. *Adv. Hort. Sci*, **32(2):** 265-272.
43. Souri, M.K., Naiji, M. and Aslani, M. 2018. Effect of Fe-Glycine Aminochelate on Pod Quality and Iron Concentrations of Bean (*Phaseolus vulgaris* L.) Under Lime Soil Conditions. *Comm. Soil Sci. Plant Anal*., **49(2):** 215-224.
44. Souri, M. K., and Hatamian, M. 2019. Aminochelates in Plant Nutrition: A Review. *J. Plant Nutr.,* **42(1):** 67-78.
45. Tohidloo, G., Souri, M. K. and Eskandarpour, S. 2018. Growth and Fruit Biochemical Characteristics of Three Strawberry Genotypes under Different Potassium Concentrations of Nutrient Solution. *Open Agric.,* **3:** 356-362.
46. Vanden Langenberg, K. M., Bethke, P. C. and Nienhuis, J. 2012. Patterns of Fructose, Glucose, and Sucrose Accumulation in Snap and Dry Bean (*Phaseolus vulgaris* L.) Pods. *Hort. Sci.,* **47:** 874-878.
47. Wagner, C. 1995. Biochemical Role of Folate in Cellular Metabolism. In: "*Folate in Health and Disease",* (Ed.): Bailey, L. B., New York, PP. 23-42.
48. Yang, L., Li, Y., Xi, G., Ma, X. and Yan, Q. 2013. Comparison of Dry Ashing, Wet Ashing and Microwave Digestion for Determination of Trace Elements in *Periostracum serpentis* and *Periostracum cicadae* by Icp-Aes. *J. Chil. Chem. Soci.,* **58:** 1876-1879.
49. Yolmeh, M. and Najafzadeh, M. 2014. Optimisation and Modelling Green Bean's Ultrasound Blanching. *Int. J. Food. Sci*., **49:** 2678-2684.
50. Yu, L., Haley, S., Perret, J., Harris, M., Wison, J. and Qian, M. 2002. Free Radical Scavenging Properties of Wheat Wxtracts. *J. Agric. Food. Chem.,* **50:** 1619-1624.
51. Zhang, B., Deng, Z. Y., Tang, Y., Chen, P. X., Liu, R. H., Ramdath, D. D. and Tsa, R. 2014. Effect of Domestic Cooking on Carotenoids, Tocopherols, Fatty Acids, Phenolics, and Antioxidant Activities of Lentils (*Lens culinaris*). *J. Agric. Food Chem*., **62:** 12585-12594.

خصوصیات مورفولوژیکی و بیوشیمیایی ارقام مختلف لوبیا سبز

آ. شیبانی راد، م. حقیقی، و ل. ابی

چکیده

لوبیا سبز (*Phaseolus vulgaris* L.) یک گیاه فصل گرم است. منشا آن مناطق آند و مزوامریکا می‌باشد. طیف وسیعی از خصوصیات مورفولوژیکی و بیوشیمیایی در میان ارقام مختلف لوبیا سبز وجود دارد. لوبیا سبز به‌خاطر نیام‌های سبز برداشت می‌شود. نیام‌ها منبع غنی از پروتئین، ویتامین‌های ضروری، کربوهیدارت‌هایی با کالری پایین، فیبر و مواد معدنی برای سلامت انسان می‌باشند. بررسی کاشت و ارزش تغذیه‌ای هشت رقم لوبیا سبز با نام‌های: پیربکران، سانری، بورپیز، ولنتاین، دراگون، کنتاکی، چروکی و آی دی مارکت نشان داد که رقم بورپیز دارای ۵۶٪ کارتنوئید، ۱۶٪ آنتی‌اکسیدان، ۶۹٪ ترکیبات فنولیک بیش‌تری نسبت به رقم مرسوم پیربکران دارد. در رقم مذکور محتوای فولات ۳۳٪ و محتوای کل آمینواسیدهای ضروری ۲۰/۶٪ نسبت به رقم پیربکران بالاتر بود. با این وجود، رقم بالارونده کنتاکی شاخص‌های رشد رویشی و عملکردی بهتری را نسبت به سایر ارقام داشت. علاوه بر این، رقم بورپیز بیش‌ترین محتوای کلسیم را تا ۴۰٪ بیش‌تر از سایر ارقام نشان داد. همچنین محتوای روی آن دو برابر بیش‌تر از ارقام ولنتاین و کنتاکی بود. در نتیجه رقم بورپیز به دلیل عملکرد نهایی بالاتر با توجه به عواملی همچون رشد رویشی و عملکرد نیام، ارزش تغذیه‌ای فراسودمند، محتوای فولات و آمینواسیدهای ضروری در مقایسه با هفت رقم مورد بررسی توصیه می گردد.