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Research Article

Effect of selenium on nutritive value of purslane (*Portulaca oleracea* L.)

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ABSTRACT

Purslane (*Portulaca oleracea*) one of the auxiliary plants was traditionally consumed in many parts of the world for its nutritional and medicinal benefits. The nutrient components of purslane such as total protein, total carbohydrates and mineral content such as macro elements (Na, K, Ca and Mg) and micro elements (Fe, Cu, Pb and Zn) were estimated at different concentrations of selenium which treated in soil where the plant cultivated. The protein and carbohydrate contents of leaves as well as protein of stems increase with increasing the selenium concentration, while protein and carbohydrate of roots as well as carbohydrate of stems decrease with increasing Se concentration. The mineral content was also affected by Se concentration, Fe, Cu and Zn of leaves decreased with increasing Se concentration, while K, Ca, Mg and Na are directly proportional with Se concentration. In stems, Zn only is inversely proportional with Se concentration. In roots, Fe, Cu, Mg and K are inversely proportional with Se concentration, while Na, Ca and Zn are directly proportional. The findings of this study revealed that carbohydrates, protein and mineral contents of purslane can be affected and controlled by selenium concentration.

Keywords: Purslane; Selenium; Food value; Mineral content.

1. INTRODUCTION

Portulaca oleracea (L.) belongs to family Portulacaceae, annual herb with succulent leaves may grow prostrate or erect depending on light availability [1], which distributed all over the world. It grows well in diverse geographical environment [2, 3]. World Health Organization considered purslane as one of the most useful medicinal plants so that named "Global Panacea" [4]. *Portulaca oleracea* is a nutritious vegetable used for human consumption [5], it can be eaten raw or cooked. It is consumed in many different parts of the world such as China, India, and Middle East countries, South East Asia, Netherlands, Mexico and United States. According to Mohamed and Hussein [6], in Middle East, purslane can be consumed raw as salad or soups. The seeds may be ground into flour as ingredient in mush bread. It is rich in antioxidant vitamins and omega-3 fatty acids [7]. Like spinach, the succulent parts of the plant, leaves and stems are edible with slightly acidic and salty taste; recently purslane become has highly nutritional value more than the major cultivated vegetables due to higher content of beta-carotene, ascorbic acid and alpha-linolenic acid [8]. Additionally, purslane with antioxidant properties and high nutritive value is considered as power food [9]. Pharaohs mentioned in Egyptian texts, purslane the earliest vegetable consumed by human [10]. In China, fresh leaves of

the plant given in liver disease, diarrhea and applied to abscesses while, in North America, seeds used to be anthelmintic and considered a cooling diuretic [11]. Purslane named pigweed, used as complementary for growth of children due to its highly content of protein and carbohydrate [12].

Humans, animals and some other microorganisms need selenium because it is essential for normal and healthy life [13]. Selenium a metalloid mineral micronutrient becomes deficient (< 40 µg/day) and toxic levels (> 400 µg/day) [14]. Low Se intake has been associated with a number of deficiency syndromes, particularly cardiomyopathy and osteoarthritis, recent research demonstrates the importance of Se to human health [15].

So far little information is available on the nutrient composition of *Portulaca oleracea*, the aim of this research was evaluate the selenium concentration on the food value of purslane that may considered this plant one of the more important foods of the future.

2. MATERIALS AND METHODS

The seeds of *Portulaca oleracea* were selected from agricultural research center of Egypt and cultivated in agricultural land which situated 2 km west of Zagazig city, Sharkia, Egypt. The agriculture was done in the time for the plant growth during summer season (May 2016). Before cultivation, land was equipped by plowing and leveling.

By following the land, germination occurred after 15 days of planting where one pair of leaves appeared then consequently growth occurred. The land was cleared from weeds weekly. Land was divided into 16 stands involving control, the area of each stand (1 m x 1 m). Two types of plant extracts (A and B) were added to soil with 3 weights (5, 7.5 and 10 g). The first extract (A) was from pollen grain of *Poa annua* carried on the seed, while the second (B) was from germinated pollen grain of *Bubleurum lancifolium*.

Each stand applied with one treatment of extracts, making combinations from different weights of these extracts to give 15 treatments represent Se concentrations, soil without selenium called control as shown in Table 1. Treatments were added 5 times with irrigation of soil, the concentration of Se in the extract was evaluated according to Khedr and Hend [16]. Experiment carried out in triplicate for each treatment of Se and control.

Table 1. Classification of stands with selenium concentrations.

Stands no.	Treatment	Se added (mole.dm^{-3})
1	A1 (5 g of A)	3
2	A2 (7.5 g of A)	4.5
3	A3 (10 g of A)	6
4	A1+B1 (5 g of A + 5 g of B)	11
5	A1+B2 (5 g of A + 7.5 g of B)	15
6	A1+B3 (5 g of A + 10 g of B)	19
7	A2+B1 (7.5 g of A + 5 g of B)	12.5
8	A2+B2 (7.5 g of A + 7.5 g of B)	16.5
9	A2+B3 (7.5 g of A + 10g of B)	20.5
10	A3+B1 (10 g of A + 5 g of B)	14
11	A3+B2 (10 g of A + 7.5 g of B)	18
12	A3+B3 (10 g of A+10 g of B)	22
13	B1 (5 g of B)	8
14	B2 (7.5 g of B)	12
15	B3 (10 g of B)	16
16	-	0

Plant samples were collected at the end of season and separated into root, stem and leaf then cleaned with fresh and distilled water for removal of soil and other particles.

2.1. Determination of mineral content

Samples were digested in 10 ml acids mixture (1 HNO_3 + 3 HCl) according to Prakash et al. [17] and the elements in samples were measured by an atomic absorption and flame photometer Shimadzu Model AA640F (Japan).

2.2. Total carbohydrates content

Total carbohydrate content was estimated by anthrone method according to Hedge and Hofreiter [18].

2.3. Total protein content

Total protein content was estimated according to Bradfort [19] by borate buffer solution (pH 8.5) and protein reagent (Coomassie brilliant blue G250).

2.4. The statistical analysis

This analysis applied here is the Two Way Indicator Species Analysis (TWINSPAN) according to Ter-Braak [20]

3. RESULTS AND DISCUSSION

3.1. Plant nutrients

In roots**,** it is clear that the content of Na in roots is higher than other macro nutrients and the highest content at (A3 + B1) treatment which contains (350.14 ppm) while, the content of Fe is higher than other trace elements and the highest content was at control (1.23 ppm) (Table 2). The ability of the plant to absorb the nutrients, rate of their absorption and distribution to functional sites affect the normal and adequate nutrition of plants [21]. The uptake and accumulation of mineral nutrients important for plant metabolism affected by the presence of selenium which causing inhibition in the absorption of K leading reduction in the K content of plants because of the harmful effect of Se on plasma membrane of root cells [22].

Table 2. Elemental analysis (ppm) in roots of *Portulaca oleracea.*

Stand no.	Se added (mole.dm^{-3})	Fe	Cu	Zn	K	Ca	Mg	Na
1	3	1.195	0.0920	0.0059	136.74	35.12	53.8	79.8
2	4.5	1.092	0.1027	0.1097	129.48	39.81	49.1	169.17
3	6	0.2638	0.0846	0.0281	76.76	36.44	91.7	194.14
4	11	0.3856	0.1060	0.0315	187.5	20.74	76.8	261.3
5	15	1.0532	0.0781	0	215	20.63	93.1	72.02
6	19	0.1550	0.0847	0	195.22	35.71	49	269.7
7	12.5	0.0356	0.0757	0.0511	108.26	28.21	48.8	233.2
8	16.5	0.8498	0.099	0	148.88	26.01	36.5	146.34
9	20.5	0.2000	0.080	0	49.01	25.42	38.2	122.52
10	14	0.0292	0.074	0	80.25	34.49	50.1	350.14
11	18	0.1333	0.079	0	61.29	52.77	93.7	142.42
12	22	0.0808	0.072	0	101.85	55.2	90.9	178.32
13	8	0.7491	0.085	0	94.89	20.24	87.9	111.17
14	12	0.0277	0.058	0	95.15	24.84	91.5	179.21
15	16	0.0802	0.090	0	57.77	24.09	85.5	204.6
16	0	1.2313	0.1228	0	163.63	32.64	143.9	67.87

In stems, the content of K in stems is higher than other macro nutrients and the highest content recorded at (A1 + B1) treatment which contains (715 ppm) while, the content of Fe is higher than others and the highest content was at (A2 + B1) treatment with (1.25 ppm) (Table 3).

Table 3. Elemental analysis (ppm) in stems of *Portulaca oleracea.*

Stand no.	Se added (mole.dm^{-3})	Fe	Cu	Zn	K	Ca	Mg	Na
1	**3**	0.1666	0.0976	0.0109	613.5	41.47	108.7	150.56
2	**4.5**	0.1802	0.0851	0.0125	266.3	43.005	50	219.2
3	**6**	0.8379	0.0944	0.0470	495.1	40.516	91.6	189.99
4	**11**	0.0915	0.084	0	715	34.50	142.2	220.54
5	**15**	0.2147	0.0813	0	484	52.22	91.4	210
6	**19**	0.077	0.0836	0	136.7	77.9	40	130.69
7	**12.5**	1.253	0.1034	0.0425	313.1	47.73	65.3	211.9
8	**16.5**	0.503	0.0996	0	275.5	30.387	61.9	198.8
9	**20.5**	0.1177	0.1087	0.0313	250	49.83	73.6	241.9
10	**14**	1.0327	0.0847	0.116	211.5	12.73	89	268
11	**18**	0.676	0.0945	0.0424	93.5	51.119	36.4	173.07
12	**22**	0.1348	0.0998	0.1115	279.6	28.94	93.6	230.83
13	**8**	0.1315	0.1045	0.2012	284.7	21	121.1	232.3
14	**12**	0.4128	0.0982	0.1309	376.8	24.856	86.4	176.6
15	**16**	0.5947	0.0854	0.0320	248.7	35.060	87.7	178.9
16	**0**	0.255	0.0587	0.266	417.2	33.35	74.2	148.31

Table 4. Elemental analysis (ppm) in leaves of *Portulaca oleracea.*

Stand no.	Se added (mole.dm^{-3})	Fe	Cu	Zn	K	Ca	Mg	Na
1	**3**	0.114	0.0916	0.0050	421.6	44.434	184	99.59
2	**4.5**	0.0633	0.099	0.0452	334.4	49.49	145.7	117.86
3	**6**	0.1528	0.1029	0.0155	349.1	44.634	181.5	75.42
4	**11**	0.0849	0.0828	0	331.1	43.488	117.8	86.8
5	**15**	0.044	0.0856	0.0013	461.7	43.88	155	109.1
6	**19**	0.0019	0.0769	0	248.8	37.08	46.3	105.99
7	**12.5**	0.0353	0.0952	0	516.3	44.34	198.5	105.96
8	**16.5**	0.115	0.0889	0	410.2	10.63	122.54	90.85
9	**20.5**	0.350	0.0969	0	366.9	19.36	101.4	60
10	**14**	0.022	0.0849	0	408.9	51.015	141.8	130.4
11	**18**	0.0129	0.0940	0.0166	214.1	50.549	63.1	130.89
12	**22**	0.0377	0.0868	0	539.5	48.58	155.9	178.99
13	**8**	0.0481	0.1030	0	348.5	28.34	118.1	110.44
14	**12**	0.0022	0.0943	0	295.5	28.808	123	165.85
15	**16**	0.0960	0.063	0	275.8	35.01	111.3	149.12
16	**0**	0.0635	0.1070	0.055	327.2	34.27	121.8	42.98

In leaves, the content of K in leaves is more than any other element and the highest amount was at (A3 + B3) treatment which contains (539.5 ppm) while, the content of Fe is higher than other elements as well as in stems and roots and the highest content was at (A2 + B3) treatment with (0.35 ppm) (Table 4).

The nutrient composition of purslane depends on its growth stages and organs [6]. They also reported that total P, Fe and Mn content in leaves was significantly higher than those found in stems. According to [23], Ca, Mg and S tend to accumulate in leaves, while K tends to accumulate in the stem.

Ions can interact with the soil and plant in different ways, which can lead to deficiency or toxicity phenomena that affect growth and development [24, 25]. The ionic uptake by the cell is affected by the environmental salinity, which affects the relative availability of the ions in the area surrounding the root [24, 26].

In the present study, the differential accumulation of the Na^+, K^+, Ca^{2+} and Mg^{2+} in plant organs agreed with [23]. Se concentration as well as salinity, when increased, K^+ concentrations of roots and stems decreased, while Na^+ concentrations increased. The increased Na^+ with the concomitant decreased the K^+ in plant. This might be attributed to the competition and resultant selective uptake between K^+ and Na^+, which causes increase in the uptake of Na^+ at the cost of K [27-31].

3.2. Carbohydrates

The amount of carbohydrates in roots is more than in leaves and stems of purslane [6]. The highest amount of carbohydrates in roots was at (A2 + B2) treatment which contains (51.56 mg/g dry wt) while, the highest amount in stems was at (A3 + B1) treatment with (49.29 mg/g dry wt). The highest amount of carbohydrates in leaves was recorded at (B3) treatment (51.2 mg/g dry wt) as shown in Table 5.

Table 5. Amount of total protein and total carbohydrate (mg/g dry wt) in leaves, stems and roots of *Portulaca oleracea*.

Stand no.	Se added (mole.dm^{-3})	Leaves		Stem		Roots	
		Protein	Carbohydrate	Protein	Carbohydrate	Protein	Carbohydrate
1	3	44.4	25.55	32	45.59	36.06	44.6
2	4.5	38	31.3	49	36.44	45.57	24.74
3	6	38.6	15.96	31.4	35.5	32.8	26.99
4	11	58.4	39.4	34	15.64	37.67	24.94
5	15	44	44.49	34.1	28	35.2	47.49
6	19	45	17.94	43.7	18.67	18.3	31.39
7	12.5	57.2	15.7	46.2	23.72	40.4	42.56
8	16.5	45	39.4	27.5	43.94	47.3	51.56
9	20.5	48.6	19.6	33.7	43.65	32.6	15
10	14	31.8	36.9	34.5	49.29	46.2	31.5
11	18	37.5	45.22	30.3	31.19	23	39.5
12	22	37.4	24	40.7	34.19	14	21.47
13	8	46	32.6	31.2	42.3	48.7	41.79
14	12	60	49.55	32.1	46.5	43.2	32.93
15	16	42.2	51.2	40	27.7	46.7	42.15
16	0	39.5	48.5	32	37.7	43.2	36

3.3. Proteins

The amount of proteins in leaves is more than stems and roots of purslane. The highest amount of proteins in leaves was recorded at (B2) treatment with (60 mg/g dry wt) while, the highest amount in the stems was recorded at (A2) treatment with (49 mg/g dry wt) and the highest amount of proteins in roots at (B1) treatment with (48.7 mg/g dry wt) as shown in Table 5.

The protein levels in purslane cultures (control plants) were similar to or higher than those of other forage, vegetable and food crops. These high crude protein values were also reported by [32, 33] and placed purslane above alfalfa, which has a crude protein content of 17% DW, and is currently the most important commercial vegetable crop in the USA.

3.4. Effect of Se on nutrients

The correlation between selenium concentration (treatments) and elements is indicated on the ordination diagram produced by Canonical Correspondence Analysis (CCA) of the biplot of element- concentrations. The length and direction of an arrow representing a given variable provide an indication of the importance and direction of the gradient of concentration, for that variable, within the set of samples measured. The angle between an arrow and each axis is a reflection of its degree of correlation with the axis, as shown in Figures 1-3.

In roots, the canonical correspondence analysis (CCA) ordination show protein, carbohydrates and Zn are separated at the right and upper side of the CCA diagram closely related to 8, 4.5, 11 and 16 mole.dm^{-3} of Se. Cu, Fe, K and Mg are separated at the right and lower side of the CCA diagram. Protein and carbohydrates are separated at the lower and left side of CCA diagram exhibit a close relationship with 3 and 15 mole.dm^{-3} of Se. Ca is separated at the left and lower side of CCA diagram affected by 18 and 22 mole.dm^{-3} Se concentrations while Na is separated at the upper and left side of CCA diagram closely related to 12.5, 14, 12 and 20.5 mole.dm^{-3} Se concentrations as shown in Figure 1.

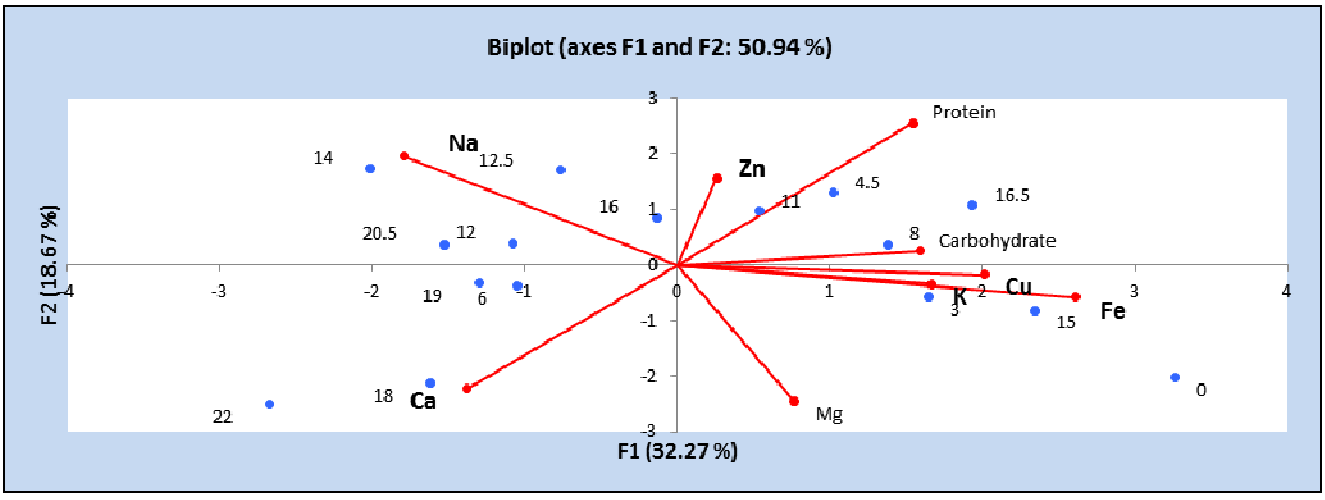

Figure 1. Canonical Correspondence Analysis (CCA) ordination diagram of elemental content in roots and the selenium concentrations.

The content of Ca, Zn, carbohydrates and proteins in roots increase with an increase in Se concentration, while K, Cu, Fe, Mg and Na decrease with increasing the Se concentration.

In stems, (CCA) ordination show Ca is separated at the right and upper side of the CCA diagram closely related to 16 and 19 mole.dm^{-3} of Se. Protein is separated at the right and lower side of the CCA diagram affected by 4.5, 18 and 12.5 mole.dm^{-3} Se concentrations. Carbohydrates, Na and Zn are separated at the lower and left side of CCA diagram exhibit a close relationship with

14, 20.5, 12, 16.5 and 22 mole.dm^{-3} of Se. K and Mg are separated at the left and upper side of CCA diagram affected by 11, 3 and 6 mole.dm^{-3} Se concentrations as shown in Figure 2.

The content of Ca, Na, Zn and carbohydrates in stems increase with an increase in Se concentration, while K, Fe, Mg and protein decrease with increasing the Se concentration.

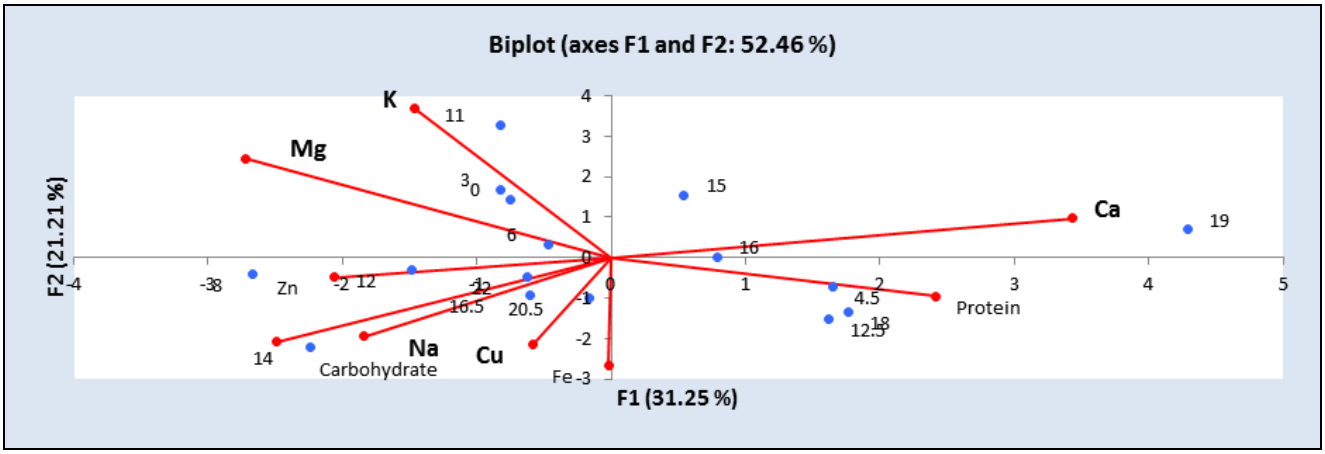

Figure 2. Canonical Correspondence Analysis (CCA) ordination diagram of elemental content in stems and the selenium concentrations.

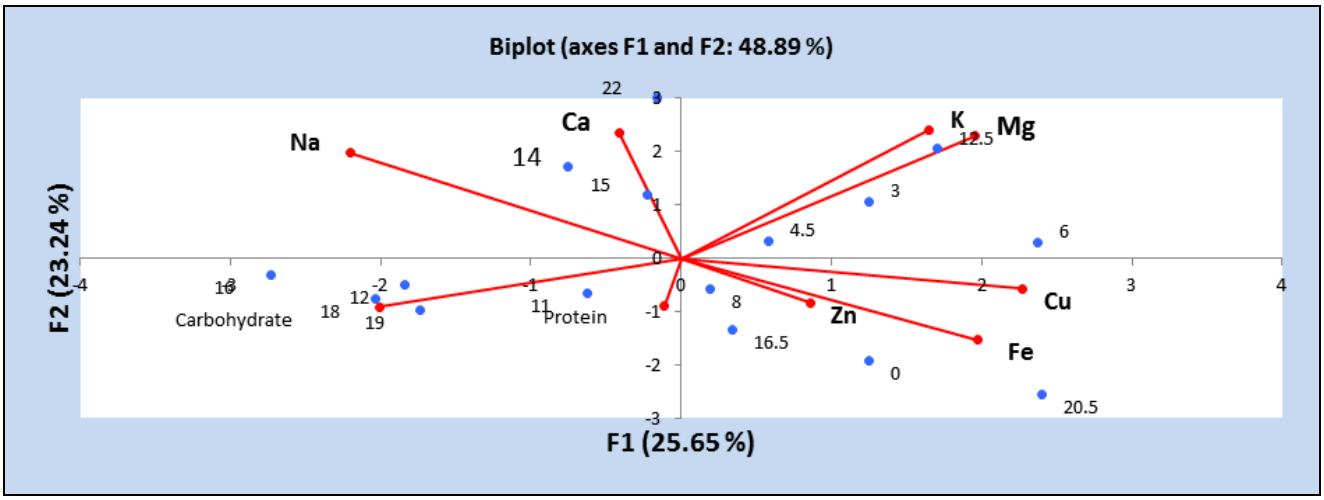

Figure 3. Canonical Correspondence Analysis (CCA) ordination diagram of elemental content in leaves and the selenium concentrations.

In leaves, (CCA) ordination show K and Mg are separated at the right and upper side of the CCA diagram closely related to 12.5 mole.dm^{-3} of Se. Cu, Fe, Zn are separated at the right and lower side of the CCA diagram affected by 16.5 and 8 mole.dm^{-3} Se concentrations. Protein and carbohydrates are separated at the lower and left side of CCA diagram exhibit a close relationship with 12, 18 and 19 mole.dm^{-3} of Se. Na and Ca are separated at the left and upper side of CCA diagram affected by 14 and 15 mole.dm^{-3} Se concentrations as shown in Figure 3.

The content of K, Mg, carbohydrates and proteins in leaves increase with an increase in Se concentration, while Cu, Fe, Zn, Ca and Na decrease with increasing the Se concentration.

Selenium with high level acts as a prooxidant and cause damage to plants however, at low level it has positive effect on growth of plants, counteracting many types of environmental stresses such

as heavy metals and stimulating plant growth [34]. There are studies carried out on different Se fertilization methods as well as different crops such as common purslane [35].

4. CONCLUSION

In conclusion, the carbohydrates and protein of leaves and stems were increased with increasing the selenium concentration, while in roots decreased with increasing Se concentration. The mineral content was also affected by Se concentration, Fe, Cu, and Zn in leaves decreased with increasing Se concentration, while Na, Ca, K and Mg are directly proportional with Se concentration.

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AUTHOR'S CONTRIBUTION

KHF, HM: are supervisors of Ph.D thesis of SHA, wrote and revised the manuscript; SHA: experimental work; KHF, HM: statistical analysis, figures and wrote the first draft. All authors read and approved the final manuscript.

TRANSPARENCY DECLARATION

The authors declare that there is no conflict of interest regarding the publication of this article.

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