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Monitoring of selected macro and microelements in some sprouted legume seeds by microwave-assisted digestion and ICP-OES

Fatma Gökmen Yılmaz[1], Mehmet Musa Özcan[2], Ayşegül Korkmaz[1], Mustafa Mete Özcan[3,*]

[1]Department of Soil Science and Plant Nutrition, Faculty of Agricultural, University of Selçuk, 42031, Konya-Turkey
[2] Faculty of Agriculture, Department of Food Engineering, Selcuk University, 42031 Konya, Turkey
[3] Aydoganlar High Vocational College, Selcuk University, Karapınar, Konya, Turkey

**Corresponding author: mozcan@selcuk.edu.tr*

Abstract

K and P amounts of untreated (control) and germinated legume seeds were recorded to be between 4939.97 (Barbunya bean shell) and 14113.25 mg/kg (Barbunya sprout) to 1690.42 (Soaked barbunya bean shell) and 13131.59 mg/kg (soaked Barbunya seed without Shell), respectively. In addition, while Ca values of barbunya bean samples are established between 282.60 (Soaked barbunya bean without shell) and 6021.32 mg/kg (Barbunya bean cotyledon without sprout), Mg amounts of barbunya bean samples were recorded to be between 2026.31 (Soaked barbunya bean without shell) and 2018.28 mg/kg (untretated barbunya bean seed). Fe and Zn amounts of untreated (control) and germinated legume seed parts were assigned to be between 19.69 (soaked barbunya seed without shell) and 39.26 mg/kg (barbunya cotyledon without sprout) to 10.49 (soaked barbunya seed without Shell) and 28.52 mg/kg (untreated barbunya seed), respectively. While Cu contents of legume seeds are found between 6.09 (soaked barbunya seed without shell) and 11.31 mg/kg (barbunya seed), Mn values of the legume seeds were established to be between 6.80 (soaked barbunya seed Shell) and 19.84 mg/kg (barbunya cotyledon). The highest B was found in untreated barbunya seed. The highest Fe, Zn, Cu, Mn and B contents were found in lentil cotyledon (for Fe, Zn and Cu), lentil sprout and untreated pea seeds, while the lowest Fe, Zn, Cu, Mn and B contents were determined in soaked lentil seeds without seed.

Key words: pulses, legume, seeds, macro and micro elements, ICP-OES

1. Introduction

Pulses are edible seeds belonging to the Leguminosae family for human consumption and consist of various species such as beans (*Phaseolus vulgaris* L.), peas (*Pisum sativum*), lentils (*Lens culinaris*), chickpeas (*Cicer arietinum* L.) and faba beans (*Vicia faba*). They contain almost twice as much protein, especially compared to cereal grains. In addition, legumes are an excellent source of macro- and micro-nutrients (Zhou *et al*. 2023). Beans (*Phaseolus vulgaris* L.), peas (*Pisum sativum*), chickpeas (*Cicer arietinum* L.), cowpeas (*Vigna unguiculata*), lentils (*Lens culinaris*), broad beans (*Vicia faba*), pigeon peas (*Cajanus cajan*) are among the important crops produced worldwide. legumes (Calles, 2016; Rawal and Navarro, 2019). Pulses constitute a subclass of legumes produces edible seeds for human and animal consumption (FAO, 1994). Legumes, which are the second most important product in human nutrition after grains, have special importance in meeting the need for plant protein (Siddiq and Uebersax, 2012; Semba *et al.* 2021). Legumes such as chickpeas, cowpeas, lentils and soybean play a role in increasing soil fertility due to the nitrogen fixation feature of their roots, which leads to reducing the use of nitrogenous fertilizers and increasing crop production (Magrini *et al.* 2016; Venkidasamy *et al.* 2019; Arif *et al*. 2021). Increasing awareness of the importance

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of food diversity for human health has led to increased consumption of legumes rich in protein and minerals by consumers (Carbas *et al.* 2021). Legumes such as chickpeas, lentils and peas, which are grown and consumed worldwide, constitute the source of important protein, vitamins, dietary fiber, minerals and phyto-chemicals (Şengül and Çalışlar 2020; Hamid *et al.* 2020). In developing countries where protein-energy malnutrition is common, legumes are consumed as a staple food and cheap protein source due to their high protein content, dietary fiber, starch, minerals and vitamins (Sozer *et al.* 2017). In addition, legumes and legume flour products are also used as gluten-free diets to improve the nutrition of the individual in celiac disease (Niewinski *et al.* 2008). Peas, beans, lentils, chickpeas and broad beans and similar legumes contain many bioactive substances in their structures, including enzyme inhibitors, lectins, phytates, oligosac-charides and phenolic compounds (Campos-Vega *et al.* 2010; Tharanathan and Mahadevamma, 2003; Rochfort and Panozzo, 2007). Determining minerals in foodstuffs is very important from a nutritional and toxicological perspective. In addition, copper, chromium, iron and zinc play an important role in human metabolism, and interest in these elements is increasing due to their relationship between trace element status and oxidative diseases (Fennema, 2000). Pulses represent dry grain legumes for human consumption, which are frequently advocated in Western diets due to their beneficial nutritional effects and being a low-cost source of protein and minerals (Sandberg, 2002). During the germination process, which is defined as the process of seeds coming out of a dormant period and starting to sprout in a suitable environment, various enzymes and phytochemicals are produced to provide the nutrients necessary for the vital activities of the seeds after germination (Lorenz & D'Appolonia, 1980). Edible germinated cereal seeds are of great interest as a source of active ingredients used in healthy functional foods and cosmetics, increasing the nutritional quality and amount of bioactive constituents in cereals (Donkor et al., 2012; Singh *et al.*, 2015). Although various processing methods are applied to produce pulses and pulse-based products due to their storage and nutrient enrichment needs, individual processing methods have different specific effects on legume biogenic elements, including their content, bioaccessibility and bioavailability. Therefore, the aim of this study was to investigate the effect of germination on the macro and micro element contents of different parts of some legume seeds.

2. Material and methods

2.1. Material

Pulse and legume seed samples were provided from Konya provinces in 2023. Before the analysis, the seeds were cleaned. HNO_3 and H_2O_2 are analytical grade and Merck company (Darmstadt, Germany). The places where the fruits used in this study were collected are shown on the map below (Fig.1).

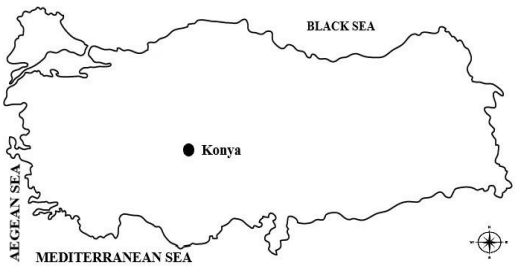

Figure 1. Locations where the seeds used in this study were collected

2.2. Germination processing

Legume seeds were selected to be 105 g in equal size, and the seed shells were peeled by keeping them between cotton soaked in 150 ml of pure water for 6 hours. After the shells and seeds were dissolved separately in the microwave (Arçelik MD 595, TÜRKİYE) device, the elements were determined in the ICP-OES (Agilent-51110) device. Additionally, legume seeds were placed among cotton in petri dishes for germination. It was germinated by keeping it in 95% relative humidity, 25°C temperature and unlit environment for 3-7 days. Then, the samples were separated and dissolved separately in the microwave device, and the elements were determined in the ICP-OES device.

2.3. Macro-, micro and heavy metal contents of seed samples

After 0.2 g seed samples were inginerated in a microwave device at 210ºC and 200 PSI pressure in 5 ml of concentrated HNO_3 and 2 ml of H_2O_2 (30% w/v), the volumes of the dissolved samples were completed to 20 ml with deionized water. Then, heavy metal concentrations in the samples were analyzed with ICP-OES (Tošic *et al.*, 2015).

Table 1 Wavelengths, detection LOD (mg/kg), Limit of Quantification LOQ (mg/kg), Coefficient of determination (R2) of elements analyzed with ICP-OES

Elements	Wavelengths (nm)	Detection LOD (mg/kg)	Limit of Quantification LOQ (mg/kg),	Coefficient of determination (R^2)
B	249.772	0.118227	0.394091	0.999
Ca	317.933	259.2863	864.2877	0.999
Cu	327.395	0.027818	0.092727	0.999
Fe	238.204	1.411773	4.705909	0.999
K	766.491	131.6843	438.9477	0.999
Mg	279.553	58.98845	196.6282	0.999
Mn	257.610	0.424227	1.414091	0.999
P	213.618	4.346591	14.48864	0.999
Zn	213.857	0.208636	0.695455	0.999

Table 2 Concentrations of calibration solutions of nutritional elements (Std: Standard solution)

Elements	Blank	STD-1	STD-2	STD-3	STD-4	STD-5	STD-6	STD-7	STD-8	STD-9	STD-10	STD-11	STD-12
	(ppm)												
B	0	1	2	4	8	16	32	64	128	256			
Ca	0	1	2	4	8	16	32	64	128	256			
Cu	0	1	2	4	8	16	32	64	128	256			
Fe	0	1	2	4	8	16	32	64	128	256			
K	0	1	2	4	8	16	32	64	128	256			
Mg	0	1	2	4	8	16	32	64	128	256			
Mn	0	1	2	4	8	16	32	64	128	256			
P	0										1	2	8
Zn	0	1	2	4	8	16	32	64	128	256			

2.4. Statistical analysis

The JMP statistical program was used for the statistical analysis of results obtained. Statistically differences were determined by the analysis of variance (ANOVA) procedure in all data ($p<0.01$ and $p<0.05$) (Savaşlı *et al*., 2019).

3. Results and discussions

Macro element contents of different parts of raw (control) and some germinated legume seeds are given in Table 3. The element found in the highest amounts in raw and germinated legume seeds was K, followed by P, Mg and Ca in decreasing order. It is thought that the variety, genetics, germinated seed parts and the soaking and germination process have an effect on these differences in the macro element amounts of seeds and parts. K and P amounts of untreated (control) and germinated legume seeds were recorded to be between 4939.97 (Soaked barbunya bean Shell) and 14113.25 mg/kg (Barbunya sprout) to 1690.42 (Soaked barbunya bean shell) and 13131.59 mg/kg (soaked barbunya seed without Shell), respectively. In addition, while Ca values of barbunya bean samples are established between 282.60 (Soaked barbunya bean without shell) and 6021.32 mg/kg (Barbunya bean cotyledon without sprout), Mg amounts of barbunya bean samples were recorded to be between 2026.31 (Soaked barbunya bean without shell) and 2018.28 mg/kg (untretated barbunya bean seed). While P amounts of pea and germinated pea seed parts vary between 929.39 (Soaked pea seed Shell) and 1027.61 mg/kg (untretaed pea), K contents of pea parts were detected to be between 5512.66 (Soaked pea seed Shell) and 18616.11 mg/kg (pea cotyledon without sprout). Also, Ca and Mg amounts of untreated and germinated pea seed parts were assigned to be between 121.76 (soaked pea seed without Shell) and 2141.32 mg/kg (untreated pea) to 775.21 (soaked pea seed without shell) and 2019.30 mg/kg (untreated pea), respectively. P and K contents of kidney beans, another legume, were specified to be between 1756.36 (soaked kidney bean shell) and 4169.23 mg/kg (soaked kidney bean without Shell) to 7938.66 (soaked kidney bean shell) and 12630.87 mg/kg (kidney bean sprout), respectively. Ca amount of untreated and germinated kidney

Table 3. Macroelement contents of some raw and germinated legume seeds (mg/kg)

Samples	P	K	Ca	Mg
Barbunya seed (control)	4541.64±0.848 G	5111.23±0.015 O	6012.20±0.113 B	2018.28±0.014 D
Soaked barbunya bean shell	1690.42±1.129 PQ	4939.97±34.710 O	5160.88±24.258 C	1861.54±27.742 E
soaked barbunya seed without shell	I3131.59±132.781 J	12034.07±222.179 EF	282.60±27.783 U	1016.31±25.985 M
Barbunya sprout	4160.80±19.659 H	14113.25±73.949 D	1229.49±70.595 O	1761.77±22.336 F
Barbunya cotyledon without sprout	1856.45±17.275 P	5116.49±3.326 O	6021.32±1.134 B	2014.93±2.029 D
Pea seed (control)	10275.61±17.275 A	5822.40±1.120 NO	2141.32±0.537 K	2019.30±0.577 D
Soaked pea bean shell	929.39±0.604 R	5512.66±0.325 NO	2059.53±0.441 LM	1891.41±0.347 E
Soaked pea seed without shell	4491.87±187.514 G	10308.90±482.957 FG	121.76±2.741 VW	775.21±5.205 O
Pea sprout	6272.38±3.535 F	14449.50±58.118 D	424.66±2.066 ST	1145.52±21.973 L
Pea cotyledon without sprout	7376.49±2.349 C	18616.11±19.566 C	1448.52±0.898 N	1458.67±0.833 I
Kidney bean seed (control)	2129.94±0.863 NO	8135.40±0.594 H-L	4925.84±2.403 E	2451.99±1.169 B
Soaked kidney bean shell	1756.36±2.072 PQ	7938.66±34.391 H-M	4748.42±1.379 F	2238.20±1.403 C
Soaked kidney seed without shell	4169.23±12.407 H	8753.85±130.071 GHI	392.32±1.155 T	1007.52±14.656 M
Kidney bean sprout	4040.54±15.518 H	12630.87±2.242 DE	737.48±46.037 Q	1645.44±17.887 G
Kidney bean cotyledon without sprout	1910.57±3.218 OP	9126.81±58.476 GHI	5010.32±1.183 D	2439.94±0.868 B
Bean seed (control)	6767.47±52.254 E	9621.67±0.600 GH	4563.92±5.756 G	2000.93±21.032 D
Soaked bean shell	579.16±0.563 S	1949.24±226.747 P	4402.76±0.435 H	1267.82±1.406 K
Soaked bean seed without shell	4642.77±11.553 G	14024.74±71.521 DE	319.54±4.360 U	1408.90±27.299 I
Bean sprout	2946.54±12.849 JK	8412.05±12.997 G-J	113.86±1.897 W	775.54±15.007 O
Bean cotyledon without sprout	6300.93±3.779 F	25082.64±4.510 B	496.02±1.187 R	1344.22±2.187 J
Lentil seed (control)	3131.59±4.901 J	6455.27±0.645 J-O	2122.99±1.235 KL	1519.92±2.857 H
Soaked lentil shell	2588.07±1.267 L	6069.23±107.375 L-O	2019.83±0.313 M	1319.71±0.347 J
Soaked lentil seed without shell	2550.26±149.957 LM	5298.58±245.697 MNO	190.37±3.256 V	456.48±2.204 Q
Lentil sprout	2941.46±90.786 JK	4988.12±0.296 O	1431.35±3.964 N	846.29±2.174 N
Lentil seed cotyledon without sprout	7146.41±12.938 D	14564.11±0.311 D	1065.63±23.775 P	1134.88±21.792 L
Chickpea seed (control)	1719.07±0.752 PQ	8145.68±0.889 H-K	2317.98±1.489 J	2680.70±0.299 A
Soaked chickpea seed shell	1575.94±2.332 Q	6310.37±237.611 K-O	20292.07±6.692 A	2478.96±4.677 B
Soaked chickpea seed without shell	2341.04±25.302 MN	7465.26±84.414 I-N	477.98±12.441 RS	669.50±10.092 P
Chickpea sprout	2862.49±27.599 K	6798.59±155.450 G-K	1261.89±19.421 O	1347.39±23.288 J
Chickpea seed cotyledon without sprout	7753.01±125.121 B	27315.30±89.934 A	2437.52±18.050 I	1529.11±11.050 H

ab; $p<0.05$, **A,B**; $p<0.01$

bean samples contained to be between 392.32 (soaked kidney bean seed without shell) and 5010.32 mg/kg (kidney bean cotyledon without sprout), while Mg amounts of kidney bean parts are stated between 1007.52 (soaked kidney bean seed without shell) and 2451.99 mg/kg (untretaed kidney bean seed). While P amounts of been seed and germinated bean parts change between 579.16 (soaked been Shell) and 6767.47 mg/kg (untreated bean), K

contents of bean seed amd parts were recorded to be between 1949.24 (soaked bean Shell) and 25082.64 mg/kg (bean cotyledon wirhout sprout). In addition, Ca and Mg values of bean seed and germinted bean parts were reported to be between 113.96 (bean sprout part) and 4563.92 mg/kg (untreated bean seed) to 775.54 (bean sprout) and 2000.93 mg/kg (untreated bean seed), respectively. P and K contents of lentil seed and germinated lentil seed parts were recorded to be between 2588.07 (soaked lentil Shell) and 7146.41 mg/kg (lentil cotyledon without sprout) to 4988.12 (lentil sprout) and 14564.11 mg/kg (lentil cotylşedon without sprout), respectively. Also, while Ca values of lentil seeds change between 190.37 (soaked lentil seed without Shell) and 2122.99 mg/kg (untreated lentil seed), Mg amounts of lentil seed and germinated parts were identified to be between 456.48 (soaked lentil seed without shell) and 1519.92 mg/kg (untreated lentil seed). The P and K contents of chickpeas, another legume, were found to be between 1575.94 (soaked chickpeas Shell) and 7753.01 mg/kg (chickpea cotyledon without sprout) to 6310.37 (soaked chickpea Shell) and 27315.30 mg/kg (chickpea cotyledon without sprout), respectively. In addition, while Ca amounts of chickpea seed and germinated chickpea parts are determined between 477.98 (soaked chickpea seed without Shell) and 20292.07 mg/kg (soaked chickpea Shell), Mg contents of chickpea seeds were recorded to be between 669.50 (soaked chickpea seed without Shell) and 2680.70 mg/kg (untreated chickpea seed). As a result, the highest P and Mg contents of legume seeds were found in the untreated seed (control) parts (except P for chickpea). In addition, the lowest Mg contents of legume seeds were detected in soaked seeds without shell. In Legume seeds, the highest K was determined in the cotyledon without sprout section (except for kidney beans). The highest K in red kidney beans was detected in the "red bean sprout" part. Interestingly, the parts with the lowest Ca content in legume seeds were the "seed without shell" and "chickpea sprout" parts. In peas, kidney beans, cowpeas, bean and chickpea, the lowest P and K were detected in the "soaked seed shell" part. It has been observed that some macro elements are localized in different parts of the seeds during germination in legume seeds. The decrease in the elements in the seeds may be due to their transfer to the soaking water or their use as a nutrient source during germination.

Microelement contents of some untreated and germinated legume seed parts are given in Table 4.

Table 4. Microelement contents of some raw and germinated legume seeds (mg/kg)

Samples	Fe	Zn	Cu	Mn	B
Barbunya seed (control)	37.57±0.281 F	28.52±0.011 E	11.31±0.008 DE	9.81±0.003 KL	21.46±0.023 B
Soaked barbunya bean shell	35.82±0.343 G	16.42±0.008 KL	8.17±0.017 H	6.80±0.044 N	15.07±0.019 G
soaked barbunya seed without shell	19.69±0.427 M	10.49±1.522 O	6.09±0.487 LM	9.30±1.349 KLM	5.47±0.256 OP
Barbunya sprout	20.49±0.238 OP	25.11±0.769 F	7.46±0.157 I	14.15±0.410 G	8.40±0.185 L
Barbunya cotyledon without sprout	39.26±0.574 F	18.52±0.018 IJ	10.56±0.322 F	19.84±0.262 E	18.29±0.059 DE
Pea seed (control)	21.28±0.021 LM	28.23±0.014 E	9.13±0.015 G	12.40±0.004 HI	14.21±0.007 H
Soaked pea bean shell	10.81±0.008 Q	16.09±0.361 KL	1.00±0.013 Q	2.96±0.011 O	9.87±0.036 K
Soaked pea seed without shell	10.48±0.116 Q	24.61±0.196 FG	6.33±0.011 KL	8.25±0.097 M	6.62±0.228 MN
Pea sprout	15.80±0.029 N	28.38±0.169 E	8.82±0.055 G	16.49±0.149 F	5.14±0.073 PQ
Pea cotyledon without sprout	31.62±0.316 H	43.32±0.008 B	14.60±0.012 B	8.28±0.015 MI	12.39±0.008 I
Kidney bean seed (control)	95.43±0.087 AB	28.15±0.004 E	13.19±0.065 C	12.23±0.121 I	12.24±0.009 C
Soaked kidney bean shell	93.89±0.119 B	8.88±0.014 P	11.88±0.019 D	8.85±0.020 LM	16.77±0.013 F

Samples	Fe	Zn	Cu	Mn	B
Soaked kidney seed without shell	22.50±0.822 KL	21.52±0.209 H	6.58±0.241 KL	8.75±0.191 LM	6.81±0.013 MN
Kidney bean sprout	12.18±0.121 Q	25.41±0.129 F	8.60±0.166 GH	26.53±0.143 C	16.36±0.013 F
Kidney bean cotyledon without sprout	96.99±0.135 A	10.33±0.054 O	13.97±0.068 B	10.38±0.002 JK	18.48±0.046 CD
Bean seed (control)	30.69±0.567 HI	36.30±0.072 C	15.44±0.015 A	20.59±0.294 DE	11.21±0.303 J
Soaked bean shell	13.97±0.006 O	2.00±0.011 R	0.99±0.005 Q	1.99±0.005 O	8.10±0.062 L
Soaked bean seed without shell	16.56±0.187 N	19.75±0.448 I	6.07±0.282 LM	12.41±0.228 HI	6.06±0.306 NO
Bean sprout	19.60±1.805 M	12.10±0.079 N	2.33±0.012 P	6.47±0.189 N	3.99±0.789 R
Bean cotyledon without sprout	23.16±0.030 K	36.15±0.030 C	12.90±0.053 C	10.24±0.090 JK	7.26±0.024 M
Lentil seed (control)	28.27±0.061 J	15.16±0.003 LM	10.28±0.014 F	11.22±0.007 IJ	15.22±0.010 G
Soaked lentil shell	23.47±0.020 K	10.78±0.013 O	6.85±0.002 JK	9.78±0.012 KL	12.76±0.026 I
Soaked lentil seed without shell	13.33±0.268 OP	8.78±0.022 P	5.70±0.151 MN	8.58±0.174 M	1.88±0.061 S
Lentil sprout	42.57±0.369 E	17.30±0.013 JK	7.44±0.151 IJ	13.62±0.056 G	6.61±0.177 MN
Lentil seed cotyledon without sprout	60.31±0.322 C	32.67±0.023 D	10.76±0.394 EF	8.69±0.078 LM	11.25±0.377 J
Chickpea seed (control)	45.27±0.024 D	21.21±0.09 H	5.21±0.003 N	192.74±0.512 A	23.26±0.995 A
Soaked chickpea seed shell	43.94±0.007 DE	3.51±0.027 Q	2.32±0.006 JK	180.21±0.593 B	18.51±0.009 CD
Soaked chickpea seed without shell	15.76±0.068 N	14.55±0.022 M	2.85±0.018 P	11.34±0.014 IJ	4.47±0.230 QR
Chickpea sprout	20.41±0.121 M	23.58±0.065 GF	4.26±0.050 O	26.64±0.137 C	5.56±0.108 OP
Chickpea seed cotyledon without sprout	29.56±0.791 IJ	45.41±0.187 A	15.45±0.077 A	21.70±0.221 D	17.59±0.289 E

ab; $p<0.05$, **A,B**; $p<0.01$

The results showed changes depending on the seed parts after soaking and germination. Fe and Zn amounts of untreated (control) and germinated legume seed parts were assigned to be between 19.69 (soaked barbunya seed without shell) and 39.26 mg/kg (barbunya cotyledon without sprout) to 10.49 (soaked barbunya seed without Shell) and 28.52 mg/kg (untreated barbunya seed), respectively. While Cu contents of legume seeds are found between 6.09 (soaked barbunya seed without shell) and 11.31 mg/kg (barbunya seed), Mn values of the legume seeds were established to be between 6.80 (soaked barbunya seed Shell) and 19.84 mg/kg (barbunya cotyledon). The highest B was found in untreated barbunya seed. In lentil samples, the highest Fe, Zn, Cu, Mn and B contents were found in lentil cotyledon (for Fe, Zn and Cu), lentil sprout and untreated pea seeds, while the lowest Fe, Zn, Cu, Mn and B contents were found in soaked lentil seed without seed. was determined in soaked lentil shell (for Zn, Cu and Mn) and lentil sprout samples. In general, microelement contents of soaked lentil Shell and soaked lentil seed without Shell samples were found to be lower than other lentil samples. In addition, the lentil sprout sample contains low amounts of B.

Fe and Zn amounts of kidney bean samples were specified to be between 12.18 (kidney bean sprout) and 96.99 mg/kg (kidney bean cotyledon) to 8.88 (soaked kidney bean Shell) and 28.15 mg/kg (untreated kidney bean seed), respectively. While Cu amounts of kidney bean samples vary between 6.58 (soaked kidney bean seed without Shell) and 13.97 mg/kg (kidney bean cotyledon), Mn contents of kidney been seed samples were stated to be between 8.75 (soaked kidney bean seed without Shell) and 26.53 mg/kg (kidney

bean sprout). Also, the lowest and highest B in kidney bean samples were defined to be between 6.81 (soaked kidney bean seed without Shell) and 18.48 mg/kg (kidney bean cotyledon), respectively. It can be seen that the highest Fe, Cu and B contents in cowpea samples were detected in the kidney bean cotyledon sample. In bean samples, the highest Fe, Zn, Cu, Mn and B were detected in the untreated bean sample, while the lowest Fe, Zn, Cu, Mn were found in the soaked bean shell sample. The lowest B content in bean samples was assigned in bean sprout (3.99 mg/kg). After the untreated bean sample, the highest microelement concentrations (except Mn) were determined in the bean cotyledon sample. While Fe amounts of lentil samples vary between 13.33 (soaked lentil without Shell) and 60.31 mg/kg (lentil cotyledon), Zn contents of lentil samples were specified to be between 8.78 (soaked lentil seed without Shell) and 32.67 mg/kg (lentil cotyledon). In addition, Cu and Mn amounts of untretaed and germinated lentil samples were recorded to be between 5.70 (soaked lentil seed without Shell) and 10.76 mg/kg (lentil ctyledon) to 8.58 (soaked lentil seed without Shell) and 13.62 mg/kg (lentil sprout), respectively. Also, B amounts of lentil samples varied between 1.88 (soaked lentil seed without Shell) and 15.22 mg/kg (untreated lentil seed). Fe and Zn amounts of untreated and germinated chickpea samples were determined between 15.76 (soaked chickpea seed without Shell) and 45.27 mg/kg (untreated chickpea seed) to 3.51 (soaked chickpea shell 9 and 45.41 mg/kg (chickpea cotyledon), respectively. In addition, while Cu contents of chickpea samples are found between 2.32 (soaked chickpea shell) and 15.45 mg/kg (chickpea cotyledon), Mn amounts of chickpea samples were defined to be between 11.34 (soaked chickpea seed without Shell) and 192.74 mg/kg (untreted chickpea seed). Also, the lowest and the highest B (4.47 and 23.26 mg/kg) amounts were assingned to be between "soaked chickpea seed without shell" and "untretaed chickpea seed" samples, respectively. be rich in Zn. At the end of the germination process of Legume seeds, there were significant differences in the microelement contents of different parts of the time, agronomic conditions and the plant's seeds. These differences may be due to the applied process, as well as the variety, harvest capacity to absorb nutrients from the soil. Fe, Mn and B contents in untreated chickpea and soaked chickpea shell samples were higher than other chickpea parts. In addition, chickpea sprout and chickpea cotyledon were found to

Bean, pea and chickpea and lentil contained 7, 7.36, 6.96 and 7.50 mg/100g Fe, 3.0, 3.01, 3.54 and 3.73 Zn, 197, 96, 124 and 71 Ca and 250, 132, 155 and 129 mg/100g Mg, respectively (Fachmann *et al.* 2000). The levels of minerals in legumes generally range between 1.5–5.0 µg/g Cu, 0.05–0.60 µg/g Cr g, 18.8–82.4 µg/g Fe g, 32.6–70.2 µg/g Zn, 2.7-45.8 µg/g Al g, 0.02–0.35 µg/g Ni g, 0.32–0.70 µg/g Pb (Cabrera *et al.* 2003). Thavarajah et al. (2008) showed that Saskatchewan-grown lentils contain 425-673 mg/kg of Se depending on location, soil characteristics, and growing conditions. The concentrations of Cu, Fe, Mn, Zn, and Ni were varied from 23.6-48, 67.7-132.3, 15-26.5, 37.6-68.2, and 25.5-33.3 in chickpea, 39.8-80.5, 116.1-180.5, 12.1-21.6, 36.4-57.2, and 25.4-34.1 for lentil and 32-64.2, 51.6-100.0, 6.3-15, 25.3-42.5, and 25.5-48.5 mg/kg for peas, respectively (Muche et al. 2023). Beans of Indian origin contained 9-22 Cu, 108-150 Fe and 50-109 µg/g) Zn (Vadivel and Janardhanan, 2000). Lentil seeds of Spain and UK origin contained 2.5 and 9.1 Cu, 70 and 122 Fe and 55 and 48 µg/g) Zn, respectively (Elhardallon and Walker, 1992; Jimenez *et al.* 1998). In general, Fe concentration was found to be low in all sampling areas. According to the results of this study, Fe concentrations in the samples are below the WHO standard value of 425.5 mg/kg (WHO 2001). Macro and micro element contents of different legumes differed according to seed parts depending on seed types and treatments applied. When the amounts of macro and micro elements in seeds are compared with the results of studies conducted by Fachmann *et al.* (2000), Cabrera *et al.* (2003), Muche *et al* (2023), Vadivel and Janardhanan (2000), our findings are high according to some element amounts. These differences may possibly be due to seed type, germination conditions and duration.

Conclusion

The element found in the highest amounts in raw and germinated legume seeds was K, followed by P, Mg and Ca in decreasing

order. the highest P and Mg contents of legume seeds were found in the untreated seed (control) parts (except P for chickpea). In addition, the lowest Mg contents of legume seeds were detected in soaked seeds without shell. In Legume seeds, the highest K was determined in the cotyledon without sprout section (except for kidney beans). The highest K in red kidney beans was detected in the "red bean sprout" part. In peas, kidney beans, cowpeas, bean and chickpea, the lowest P and K were detected in the "soaked seed shell" part. microelement contents of soaked lentil Shell and soaked lentil seed without Shell samples were found to be lower than other lentil samples. In addition, the lentil sprout sample contains low amounts of B. At the end of the germination process of Legume seeds, there were significant differences in the microelement contents of different parts of the seeds.

Conflicts of interest/Competing interests:
No conflict of interest

Ethics approval: No ethic situation.

Availability of data and material: The data have been reviewed depending on the literature.

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