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Monitoring of changes in the macro- and micro-element and heavy metal contents of soaked, roasted, boiled chickpea (*Cicer arietnum* L.) grains and processed waters

Überwachung der Veränderungen des Gehalts an Makro- bzw. Mikroelementen und Schwermetallen in eingeweichten, gerösteten und gekochten Kichererbsenkörnern (Cicer arietnum L.) sowie in Verarbeitungswasser

Mehmet Musa Özcan[1]), Duygu Akçay Kulluk[2]), Fatma Gökmen Yılmaz[2]), Mustafa Mete Özcan[3]), Nesim Dursun[2])

Summary

In this study, the effects of different processing ways such as roasting, soaking and boiling on heavy metal, macro and micro element contents of chickpea grains were investigated. P and K amounts of raw (control) and processed chickpea seeds were measured between 59.20 (Boiled chickpea) and 4238.69 mg/kg (control) to 600.77 (Boiled chickpea water) and 7883.69 mg/kg (Dry roasted chickpea), respectively. Fe and Mn amounts of raw (control) and processed chickpea seeds were recorded between 0.59 (Soaked chickpea water) and 58.87 mg/kg (Dry roasted chickpea) to 0.63 (Boiled chickpea water) and 27.04 mg/kg (Dry roasted chickpea), respectively. Al ve As contents of raw and processed chickpea seeds were measured between 0.75 µg/g (Boiled chickpea water) and 17.81 (control) to 3.93 (Boiled chickpea) and 9.50 µg/g (Dry roasted chickpea), respectively. In addition, Pb amounts of chickpea seeds were determined between 0.188 (Boiled chickpea) and 0.928 µg/g (Dry roasted chickpea).

Keywords: Chickpea, cooking ways, macro-and micro element, heavy metals, ICP-OES

Introduction

Chickpea (*Cicer arietinum* L; *Leguminosae* family) as Garbanzo bean or Bengal gram is one of the most consumed legumes in the World, and it grows mainly in tropical and subtropical regions (Lev-Yadun et al., 2000; Alajaji and El-Adawy, 2006; Özcan et al., 2013). Legumes, which play an important role in the agricultural sector, contribute a lot to nutrition and are an important food source for many people in developed and developing countries (Kamchan et al., 2004; Jukanti et al., 2012; Bulbula and Urga, 2018). In addition to being an important and cheap source of legume protein that can be used instead of animal protein, chickpeas grown in many parts of the world also contain significant amounts of leucine, isoleucine, lycine, cystine and phenylalanine, methionine, tryptophane and valine, especially histidine, which is very important for the development of children (Akçin). 1988; Lev-Yadun et al. 2000; Alajaji and El-Adawy, 2006). The chemical properties of chickpeas, lentils and mung beans is affected during long-term cooking, and some essential amino acids and other nutritional values are significantly reduced (Chau et al., 1997). Like other legumes, chickpea seeds are exposed to one of the processes of soaking, sprouting, boiling, roasting, frying, steaming, so that the anti-nutritive factors in its structure are eliminated and the digestibility of chickpea seeds is increased and offered for consumption (Chau et al., 1997; Wang et al., 1997; Vijayakumari et al., 1998). However, cooking leads to significant losses in the soluble components of foods, especially vitamins and minerals (Barampama and Simard, 1995). Chickpeas such as other legumes provide essential vitamins and minerals for the grain-based daily diet of millions of people in many parts of the world. (Cabrera et al., 2003; Duhan et al., 1999). The use of chickpea grains for human nutrition has a long history and is consumed in different ways as green vegetables, soaked and roasted, boiled seeds and sauces (Abebe et al., 2006). Chickpeas, one of the plant foods that have an important place in human nutrition, are cooked in various ways depending on traditional practices and taste preferences (Attia, 1994; Huisman and Van Der Poel, 1994; Clemente et al., 1998). The objective of present study was to examine the effects of different processing ways such as roasting, soaking and boiling on heavy metal, macro and micro element contents of chickpea grains.

Material and methods

Material

Chickpea seeds (*Cicer arietinum* L.) were obtained as dry seeds from a local farmer producing chickpeas in Konya during the 2022 harvest season. The shriveled, broken, moldy seeds and foreign matter in the chickpeas have been removed. Chickpea seeds were classified as larger than 8 mm and smaller than 10 mm (8<chickpea seeds>10mm), and it was manually mixed homogeneously with chickpeas separated in each size.

Method

Boiling

After adding the chickpea seeds to a pot containing 1:4 (w/v) tap water, they were cooked at 100 °C (after starting to boil) until they soften (50 min).

Soaking

Cleaned and sorted chickpea seeds were soaked in tap water at a ratio of 1:3 (w/v) for 12 hours until easily crushed between fingers. Each group consisted of 1 kg and was made in three repetitions.

Dry roasting

The cleaned chickpea seeds were roasted in a traditional oven at 210 oC for 105 minutes. After roasting, it was cooled in a desiccator.

Soaked and roasted process

After the cleaned chickpea seeds were soaked in tap water at a ratio of 1:3 (w/v) for 12 hours, the water droplets on the surface of the chickpeas were dried with a clean cloth. Softened chickpeas were roasted in an oven at 210 °C for 10 minutes.

Boiled and roasted process

After the chickpea grains were cooked in a pot containing 1:4 (w/v) at 100 °C/50 min, boiled seeds were roasted in oven at 210 °C for 10 minutes.

Soaking and boiling waters

After the chickpea grains were cooked in a pot containing 1:4 (w/v) at 100 °C/50 ml, and soaked in a pot containing 1:3 (w/v) for 12 h, water remaining in the pot at each treatment sample was taken for analysis. The dissolved substances that settled to the bottom of the boiling water were homogenized in a shaking mixer to ensure homogeneous mixing in the liquid for analysis.

Moisture content

The amounts of moisture in chickpea samples were detected at 105 °C using an oven (hot air) up to constant weight (AOAC, 1990).

Protein contents

Nitrogen (N) content was determined by Kjeldhal apparatus and crude protein was calculated utilizing 5.75 as N conversion factor for legume protein (AOAC, 1990).

Macro-, micro and heavy metal analysis of chickpea samples

0.2 g chickpea sample was burned in a microwave device ((CEM Mars X press 6 One Touch Modeli USA) at 210 ºC and under 200 PSI pressure by adding 5 ml of concentrated HNO_3 and 2 ml of H_2O_2 (30% w/v). A 40-cell microwave was used to ensure the reliability of the analysis. After the volumes of the dissolved samples were made up to 20 ml with deionized water, the heavy metal concentrations in the samples were analyzed by Inductively coupled plasma optical emission spectrometry (ICP-OES; Agilent-5110) equipment (Tošic et al., 2015).

Se analysis of samples

After the volumes of the dissolved samples were filled to 30 ml with deionized water for Se analysis, the selenium concentration in the samples was measured with the ICP-OES device to which the ETC-60 (Electro Thermal Temperature Controller) and HS 60 (Hydride) device were connected. First, 10 ml of sample is taken and after being treated with 10 ml of hydrochloric acid, the Se (+ VI) form is reduced to the Se (+ IV) form by keeping it in a water bath at 90 °C for 20 minutes. Then, Se measurements are made by installing a hydride generator in front of the sample inlet system of the ICP-OES device.

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Statistical analysis

The JMP statistical program (JMP, SAS Institute, Cary, NC) was applied for the statistical analysis of the obtained data. Samples were taken in three groups and each group was analyzed in three replicates. Statistically significant difference ($p<0.01$) in all data was determined by analysis of variance (ANOVA) procedure (Savaşlı et al., 2019).

Results and discussion

Some chemical properties and macro element contents of raw and processed chickpea seeds and soaking and boiling waters

In this study, the effects of roasting, boiling and soaking on some chemical properties, macro-, micro element and heavy metal amounts of chickpeas were investigated. In addition, the amounts of these parameters passed into the soaking and boiling water were also determined. Moisture, protein and macro element contents of chickpeas processed with different processes are shown in Table 1. Significant differences were observed in moisture, protein and macro element contents of boiled, soaked and roasted chickpeas. As a result of the applied heat treatment, in addition to the change in the moisture content of the chickpeas, differences were also observed in the element contents. In addition, the protein contents in the boiling and soaking waters of chickpeas were found low compared to protein results of other samples. Also, the total nitrogen and macro element contents of boiled and soaked chickpeas decreased significantly low compared to protein results of other samples. While the moisture amounts of chickpea samples change to be between 3.54% (dry roasted chickpea), the crude protein amounts of raw (control) and processed chickpea seeds were determined between 9.02% (Boiled Chickpea) and 16.98% (control). It was observed that the crude protein content of processed chickpeas decreased significantly compared to the control. P and K amounts of raw (control) and processed chickpea seeds were measured between 59.20 (Boiled chickpea) and 4238.69 mg/kg (control) to 600.77 (Boiled chickpea water) and 7883.69 mg/kg (Dry roasted chickpea), respectively. Also, while Ca amounts of chickpea seeds are determined between 73.29 (Boiled chickpea water) and 1531.80 mg/kg (control), Mg contents of raw (control) and processed chickpea varied between 61.86 (Soaked chickpea water) and 2091.46 mg/kg (control). In addition, S amounts of chickpea samples changed between 62.00 (Soaked chickpea water) and 1635.82 mg/kg (Dry roasted chickpea). The lowest P, K and Ca were determined in boiled chickpea sample. Moisture, crude protein, total nitrogen and macro element contents of chickpea samples showed statistically significant differences when compared to the control ($p<0.01$). It was observed that the macro element contents of chickpeas exposed to the process decreased at different levels (except for S) when compared to the control. The reason for this decrease is probably due to the temperature and duration of soaking, roasting and boiling water, as well as the freedom of oscillation of the elements in the tissue. It was observed that the protein content of boiling and soaking waters was at the lowest levels when compared to the control and other processed chickpeas (except water samples). Total protein and Non-protein nitrogen contents of raw and boiling cooking chickpeas were 23.64 and 1.82, 23.21 and 1.42 g/100g, respectively (Alajaji and El-Adawy, 2006). The ranges for Moisture content, crude protein were 5.9–9.4% and 13.8–16.7%, respectively (Bulbula and Urga, 2018). The chickpea seeds contained 19.47–21.27% (dw) proteins (Daur et al. (2008). Protein contents of chickpea seeds were found between 14.9 and 30.6% (dw) crude protein (Chavan et al., 1986). The protein contents of the total dry seed mass and dehull chickpea seeds significantly varied between 17 and 22% to 25.3 and 28.9%, respectively (Sánchez-Vioque et al., 1999). Among the minerals, potassium was highest (6435.2–8231.7 mg kg^{-1}) followed by phosphorus (2573.9–3094.0 mg kg^{-1}) and sulphur (1710.9–2060.7 mg/kg), and copper was lowest followed by boron and manganese (Doğanay et al. 2020). Chickpea contained 875 mg potassium, 331 mg phosphorus, 105 mg calcium, 24 mg sulphur, 11.5 mg magnesium, 8.2 mg selenium, 6.2 mg iron and 3.4 mg/100g zinc (Khetarpaul, 2018). The raw and roasted chickpea seeds contained 100.3 and 99.0 mg/100g Na, 1171 and 1165 K, 252.7 and 252.0 P, 194.0 and 193.7 mg/100g Ca (Daur et al., 2008). Alajaji and El-Adawy, (2006) reported that raw, boiling, autoclaving and microwave cooking chickpea contained 870, 341, 407 and 432 K, 176, 124, 131 and 131 Ca, 176, 165, 171 and 173 Mg, 226, 195, 208 and 216 g/100g P. Our results on macro element content differed from the results of previous studies. The protein quantities of our samples were generally higher than the results of Bulbula and Urga (2018) and partially lower than the results of Sánchez-Vioque et al (1999) and Daur et al (2008). While the K content (control) of our chickpea samples was found to be similar to the results of Doğanay et al (2020), the K contents of our other chickpea samples were found to be low. In general, the S quantities of our samples were lower than the results of Doğanay et al. (2020). In addition, the macro element contents of our

TABLE 1: *Some chemical properties and macro element contents (mg/kg) of raw and processed chickpea seeds and soked- and boiled-waters.*

Sample names	Moisture %	Protein %	N	P	K	Ca	Mg	S
Chickpea (Raw-Control)	9.56±0.66^{e*}	16.98±0.44^{a}	29528.57±764.58^{a}	4238.69±596.42^{a}	6905.06±618.66^{b}	1531.80±49.21^{a}	2091.46±206.57^{a}	1362.71±31.97^{b}
Boiled Chickpea	58.20±0.78^{b}	9.02±0.09^{d}	15687.96±153.38^{d}	1997.05±233.96^{cd}	1815.57±121.64^{e}	769.90±12.69^{d}	789.67±96.61^{d}	616.52±47.26^{f}
Soaked Chickpea	57.53±0.71^{b}	9.98±0.54^{c}	17355.70±930.90^{c}	2268.83±256.51^{d}	2916.75±382.36^{d}	685.50±40.15^{d}	942.83±106.50^{cd}	782.09±94.34^{e}
Dry Roasted Chickpea	3.54±0.14^{f}	16.430.86^{a}	28579.47±1492.94^{a}	4143.97±373.72^{a}	7883.69±154.88^{a}	1279.34±102.63^{b}	1977.86±46.40^{a}	1635.82±65.58^{a}
Boiled Roasted Chickpea	45.02±1.77^{c}	12.32±0.52^{b}	21421.66±901.85^{b}	2841.70±182.43^{b}	2822.47±65.03^{d}	921.38±7.22^{c}	1096.65±62.60^{c}	962.53±13.95^{d}
Soaked Roasted Chickpea	35.51±1.66^{d}	13.05±0.68^{b}	22700.73±1188.33^{b}	2723.86±177.12^{bc}	4148.38±10.15^{c}	859.02±65.40^{c}	1278.15±51.63^{b}	1069.95±30.64^{c}
Boiled Chickpea Water	98.59±0.62^{a}	7.27±0.36^{e}	12641.90±633.58^{e}	59.20±0.91^{e}	600.77±20.07^{f}	73.29±1.54^{e}	86.41±1.11^{e}	79.06±8.04^{g}
Soaked Chickpea Water	98.36±0.43^{a}	6.73±0.58^{e}	11699.46±1014.20^{e}	91.81±1.66^{e}	986.18±69.81^{f}	79.38±0.69^{e}	61.86±0.98^{e}	62.00±2.31^{g}

*p<0.01

chickpea samples were generally found to be lower than the results of Alajaji and El-Adawy (2006). These differences may be due to the variety, type of process, growing conditions, soil characteristics, and climatic conditions.

Microelement contents of raw and processed chickpea seeds and soaking and boiling waters

Micro element quantities of raw and processed chickpea samples are depicted in Table 2. The amounts of microelements in chickpeas were found to be significantly lower than the macro element contents. The microelement quantities of the chickpea samples fluctuated compared to the control depending on the process type. These fluctuations were mostly observed in Fe and Mn, followed by B, Cu and Zn in decreasing order. Fe and Mn amounts of raw (control) and processed chickpea seeds were assessed to be between 20.57 (Soaked Chickpea) and 58.87 mg/kg (Dry roasted chickpea) to 10.20 (Boiled Chickpea) and 27.04 mg/kg (Dry roasted chickpea), respectively. While Cu quantities of chickpea seeds are determined to be between 2.77 (Boiled Chickpea) and 8.19 mg/100g (Dry roasted chickpea), Zn quantities of chickpea seeds were measured between 15.61 (Boiled Chickpea) and 31.62 mg/kg (Dry roasted chickpea). Also, B amounts of raw (control) and processed chickpea seeds were determined between 1.58 (Boiled Chickpea) and 7.30 mg/kg (Dry roasted chickpea). In general, microelement contents of boiled chickpea sample were lower than those of other processed chickpea samples (excep water samples). The microelement contents of the water obtained as a result of boiling and soaking the chickpeas were determined at very low levels. The Mn, Zn and B contents of Soaked Chickpea Water were higher than the contents of boiled chickpea water. It was observed that the microelement contents of the processed chickpeas were decreased compared to the control (except dry roasted chickpea). It was determined that processed chickpeas are rich in iron, followed by Zn, Mn, Cu and B in decreasing order. It was observed that the Fe, Cu, Mn, Zn and B contents of dry roasted chickpea chickpea were higher than raw and other processed chickpea samples. The raw and roasted chickpea seeds contained 2.93 2.71 Fe, 11.37 and 11.30 Cu, 6.87 and 6.70 Zn, 1.93 and 1.87 Mn, 4.70 and 4.67 Mg mg/100g (Daur et al., 2008). Alajaji and El-Adawy (2006) reported that raw, boiling, autoclaving and microwave cooking chickpea contained 2.11, 1.80, 1.90 and 2.03 Mn, 4.32, 3.42, 3.89 and 395 Zn, 1.0, 0.73, 0.81 and 0.94 Cu, and 7.72, 6.81, 7.10 and 7.30 g/100g Fe. From our microelement findings, Fe and Mn contents were determined by Daur et al. (2008), the

TABLE 2: *Micro element contents of raw and processed chickpea seeds and soked-and boiled-waters (mg/kg).*

Sample names	Fe	Cu	Mn	Zn	B
Chickpea (Raw-Control)	57.88±0.21^{a}*	4.36±0.63^{bc}	23.79±1.05^{b}	25.07±1.21^{b}	6.28±0.28^{b}
Boiled Chickpea	18.00±0.57^{d}	2.77±0.07^{e}	10.20±1.58^{e}	15.61±1.94^{d}	1.58±0.09^{de}
Soaked Chickpea	20.57±0.93^{d}	3.09±0.39^{de}	15.46±0.12^{d}	24.38±0.99^{b}	2.71±0.19^{c}
Dry Roasted Chickpea	58.87±5.60^{a}	8.19±0.39^{a}	27.04±2.04^{a}	31.62±0.96^{a}	7.30±1.56^{a}
Boiled Roasted Chickpea	30.08±0.04^{c}	3.66±0.50^{cd}	20.38±0.41^{c}	21.63±2.06^{c}	2.40±0.17^{cd}
Soaked Roasted Chickpea	43.04±4.33^{b}	4.85±0.69^{b}	22.05±1.52^{bc}	21.73±1.70^{c}	3.08±0.09^{c}
Boiled Chickpea Water	0.63±0.022^{e}	0.34±0.019^{f}	0.63±0.027^{f}	0.61±0.032^{e}	0.60±0.008^{e}
Soaked Chickpea Water	0.59±0.06^{e}	0.24±0.02^{f}	1.22±0.13^{f}	0.68±0.02^{e}	0.61±0.06^{e}

*p<0.01

TABLE 3: *Heavy metal contents of raw and processed chickpea seeds and soaked- and boiled-waters (µg/g).*

Sample names	Al	As	Ba	Cd	Co
Chickpea (Raw-Control)	17.81±0.449^{a}*	4.69±0.226^{cd}	2.32±0.098^{a}	0.169±0.002^{a}	0.322±0.015^{a}
Boiled Chickpea	0.814±0.030^{de}	3.93±0.809^{d}	0.818±0.017^{d}	0.015±0.002^{e}	0.128±0.006^{d}
Soaked Chickpea	1.84±0.356^{c}	4.17±0.048^{d}	0.969±0.300^{cd}	0.018±0.002^{e}	0.138±0.015^{d}
Dry Roasted Chickpea	17.38±0.763^{a}	9.50±1.61^{a}	2.21±0.058^{a}	0.174±0.004^{a}	0.259±0.044^{b}
Boiled Roasted Chickpea	1.85±0.330^{c}	5.73±0.68^{bc}	1.08±0.040^{c}	0.054±0.003^{c}	0.133±0.039^{d}
Soaked Roasted Chickpea	6.01±0.179^{b}	6.39±0.737^{b}	1.60±0.239^{b}	0.073±0.005^{b}	0.195±0.014^{c}
Boiled Chickpea Water	0.754±0.076^{e}	5.79±0.621^{bc}	0.250±0.014^{e}	0.043±0.004^{d}	0.233±0.052^{bc}
Soaked Chickpea Water	1.50±0.451^{cd}	5.22±0.425^{bcd}	0.262±0.043^{e}	0.055±0.004^{c}	0.226±0.014^{bc}

Sample names	Cr	Mo	Ni	Pb	Se
Control Chickpea	0.222±0.034^{b}*	1.91±0.150^{b}	1.70±0.039^{a}	0.815±0.088^{b}	1.01±0.033^{a}
Boiled Chickpea	0.104±0.022^{d}	0.370±0.006^{de}	0.209±0.007^{d}	0.254±0.124^{de}	0.177±0.003^{cd}
Soaked Chickpea	0.112±0.007^{d}	0.678±0.098^{c}	0.352±0.046^{c}	0.188±0.005^{e}	0.124±0.001^{e}
Dry Roasted Chickpea	0.289±0.062^{a}	2.77±0.367^{a}	1.04±0.175^{b}	0.928±0.021^{a}	0.210±0.046^{c}
Boiled Roasted Chickpea	0.163±0.009^{c}	0.515±0.051^{cd}	0.375±0.059^{c}	0.303±0.008^{d}	0.161±0.007^{cde}
Soaked Roasted Chickpea	0.164±0.010^{c}	0.752±0.228^{c}	0.460±0.083^{c}	0.224±0.036^{de}	0.143±0.001^{de}
Boiled Chickpea Water	0.106±0.018^{d}	0.224±0.029^{e}	0.171±0.005^{d}	0.565±0.021^{c}	0.337±0.337^{b}
Soaked Chickpea Water	0.105±0.002^{d}	0.505±0.020^{cde}	0.092±0.011^{d}	0.539±0.068^{c}	0.343±0.040^{b}

*p<0.01

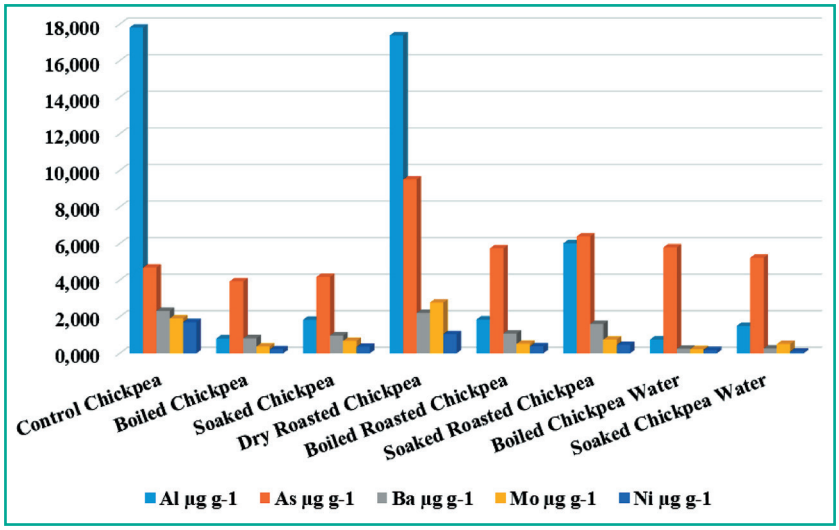

FIGURE 1: *The highest heavy metal contents of processed chickpeas.*

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Cu and Zn contents of our samples were lower (2.77–8.19 mg/kg). From our findings, while Mn was higher than the results of Alajaji and El-Adawy (2006), the Fe, Cu and Zn contents of our chickpea samples were low. These differences may possibly be due to factors such as cultivar, genetic structure, processing and analytical conditions.

Heavy metal contents of raw and processed chickpea seeds and soked – and boiled-waters

The heavy metal contents of raw and processed chickpeas are illustrated in Table 3. The heavy metals found in the highest amounts in chickpea samples were Al, As and Ba (Fig.1). The amounts of other heavy metals were found at low levels. Al ve As contents of raw ve processed chickpea seeds were measured between 0.75 µg/g (Boiled chickpea water) and 17.81 (control) to 3.93 (Boiled chickpea) and 9.50 µg/g (Dry roasted chickpea), respectively. Also, Ba and Cd contents of raw and processed chickpea seeds changed between 0.250 (Boiled chickpea water) and 2.32 µg/g (Dry roasted water) to 0.015 (Boiled chickpea) and 0.174 µg/g (Dry roasted chickpea), respectively. While Co amounts of chickpea seed samples vary to be between 0.128 (Boiled chickpea) and 0.322 µg/g (control), Cr contents of chickpea seeds were recorded between 0.104 (Boiled chickpea) and 0.289 µg/g (dry roasted chickpea). Also, Mo and Ni amounts of raw (control) and processed chickpea seeds were recorded between 0.370 (Boiled chickpea) and 2.77 µg/g (Dried roasted chickpea) to 0.092 (Soaked chickpea) and 1.70 µg/g (control), respectively. In addition, Pb and Se amounts of chickpea seeds were determined between 0.188 (Boiled chickpea) and 0.928 µg/g (Dry roasted chickpea) 0.124 (Soaked chickpea) and 1.01 µg/g control), respectively. The lowest amounts of Cd, Cu and Cr were measured in the boiled chickpea sample. In general, the heavy metal contents of the processed chickpea seeds were found to be low compared to the control. This decrease may be due to the transfer of some of the heavy metals to the boiling and soaking water. As a result of the processes applied to chickpeas, the reduction of heavy metal content is of great importance for human health in a positive way. In addition, the heavy metal contents of dry roasted chickpeas were slightly higher than that of chickpeas subjected to other processes. It is due to lower water content and a resulting higher heavy metal content. Chickpea is reported to have other trace elements including aluminum (10.2 µg /g), chromium (0.12 µg/g), nickel (0.26 µg/g), lead (0.48 µg/g), and cadmium (0.01 µg/g)] (Cabrera et al., 2003). Aletor and Ojo (1989) reported that a significant decrease in minerals was observed after cooking cowpea, and this decrease is likely due to the increased permeability of the seed coat of legumes. In other study, cooking treatments caused significant decreases in minerals of chickpeas (*Cicer arietinum* L.) (Alajaji and El-Adawy, 2006). The chemical composition of agricultural products is subject to differences depending on various internal and external factors such as variety and maturity stage, climatic factors, genetic makeup, storage, soil type, agricultural practices and technological processes (Paolini et al., 2003).

Conclusion

It was observed that the macro element contents of chickpeas exposed to the process decreased at different levels (except for S) when compared to the control. The micro-element contents of the chickpea samples fluctuated compared to the control depending on the process type. It was determined that processed chickpeas are rich in iron, followed by Zn, Mn, Cu and B in decreasing order. It was observed that the Fe, Cu, Mn, Zn and B contents of dry roasted chickpea chickpea were higher than raw and other processed chickpea samples. The heavy metals found in the highest amounts in chickpea samples were Al, As and Ba. The amounts of other heavy metals were found at low levels. The lowest amounts of Cd, Cu and Cr were measured in the boiled chickpea sample. In general, the heavy metal contents of the processed chickpea seeds were found to be low compared to the control. This decrease may be due to the heat treatment applied and the transfer of some of the heavy metals to the boiling and soaking water. As a result of the processes applied to chickpeas, the heavy metal contents of dry roasted chickpeas were slightly higher than that of chickpeas subjected to other processes.

Conflicts of interest

No conflict of interest among authors.

References

Abebe Y, Stoecker BJ, Hinds MJ, Gates GE (2006): Nutritive value and sensory acceptability of corn- and Kocho-based foods supplemented with legumes for infant feeding in Southern Ethiopia. African Journal of Food, Agriculture, Nutrition and Development, 6(1), 1–13.

Akçin A (1988): Yemeklik Dane Baklagiller, Selçuk Üniversitesi Yayınları No 43, Konya, Türkiye.

Alajaji SA, El-Adawy TA (2006): Nutritional composition of chickpea (Cicer arietinum L.) as affected by microwave cooking and other traditional cooking methods. Journal of Food Composition and Analysis 19, 806–812.

Aletor VA, Aladetimi OO (1989): Compositional evaluation of some cowpea varieties and some under-utilized edible legumes in Nigeria. Nahrung 33, 999–1007.

AOAC (1990): Official Methods of Analysis, 15 th edn. Association of Official Analytical Chemists, Washington, DC.

Attia RS (1994): Effect of cooking and decortications on the physical properties, the chemical composition and the value of chickpea (Cicer arietnum L.). Food Chemistry, 50, 125–131.

Bulbula DD, Urga K (2018): Study on the effect of traditional processing methods on nutritional composition and anti nutritional factors in chickpea (Cicer arietinum). Cogent Food & Agriculture, 4: 1, 1422370.

Cabrera C, Lloris F, Giménez R, Olalla M, Carmen Lopez M (2003): Mineral content in legumes and nuts: contribution to the Spanish dietary intake. The Science of the Total Environment, 308, 1–14.

Chavan J, Kadam A, Salunke D (1986): Biochemistry and technology of chickpea (Cicer arietinum L.) seeds. CRC Critical Reviews of Food Science and Nutrition, 25, 107–158.

Chau CF, Cheung PCK, Wong YS (1997): Effects of cooking on content of amino acids and antinutrients in three Chinese indigenous legume seeds. Journal of the Science Food Agriculture, 75, 447–452.

Clemente A, Sanchez-Vioque R, Vioque J, Bautista J, Millan F (1998): Effect of processing on water absorption and softening kinetics in chickpea (Cicer arietinum L.) seeds. Journal of the Science of Food and Agriculture, 78(2), 169–174.

Daur I, Khan IA, Jahangir M (2008): Nutrıtional quality of roasted and pressure-cooked chickpea compared to raw (Cicer arietinum L.) seeds. Sarhad Journal of Agriculture 24, 117–122.

Doğanay Ö, Köse E, Mut Z (2020): Mineral contents of chickpea cultivars (Cicer arietinum L.) grown at different locations of Turkey. Sains Malaysiana 49(2), 293–303.

Duhan A, Khetarpaul N, Bishnoi S (1999): In starch digestibility (in vitro) of various pigeonpea cultivars through processing and cooking. Ecology of Food and Nutrition 37, 557–568.

Huisman J, Van Der Poel AFB (1994): Aspects of the nutritional quality and use of cool season food legumes in animal feed. In F. J. Muehlbauer & W. J. Kaiser (Eds.), Expanding the production and use of cool season food legumes (pp. 53–76). Dordrecht: Kluwer Academic Publishers.

Jukanti AK, Gaur PM, Gowda CLL, Chibbar RN (2012): Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review. British Journal of Nutrition 108, 11–26.

Kamchan A, Puwastien P, Sirichakwal PP, Kongkachuichai R (2004): In vitro calcium bioavailability of vegetables, legumes and seeds. J. Food Comp. Anal.17, 311–320.

Khetarpaul N (2018): Total mineral content present (calcium, magnesium, potassium, phosphorus, iron, zinc, manganese, copper, and boron and nickel) in leaves of Desi and Kabuli chickpea varieties (on dry matter basis). IJCS 6(2), 633–635.

Lev-Yadun S, Gopher A, Abbo S (2000): The cradle of Agriculture Science 288, 1062–1063.

Özcan MM, Dursun N, Juhaimi FA (2013): Macro-and microelement contents of some legume seeds. Environmental Monitoring Assessment 185(11), 9295–9298.

Özcan MM,Akçay Kulluk D, Gökmen Yılmaz F, Özcan M (2022): Determination of macro-, micro-element and heavy metal contents localized in different parts of three different colored onions. Environmental Monitoring Assessment 2;194(9), 627.

Paolini R, Colla G, Saccardo F, Campiglia E (2003): The influence of plant crop density on the efficacy of mechanical and reduced chemical weed in lentil (Lens culinaris Medik). Italian Journal of Agronomy, 7, 85–94.

Sánchez-Vioque R, Clemente A, Vioque J, Bautista J, Millan F (1999): Protein isolates from chickpea (Cicer arietinum L.): chemical composition, functional properties and protein characterization. Food Chemistry, 64, 237–243.

Savaşlı E, Önder O, Karaduman Y, Dayıoğlu R, Özen D, Özdemir S, Akın A, Tunca ZS, Demir B, Aydın N (2019): The effect of soil and foliar ürea application at heading stage on grain yield and quality traits of bread wheat (Triticium aestivum L.). Turkish Journal of Agriculture Science and Technology 7, 1928–1936.

Tošic SB, Mitic SS, Velimirovic DS, Stojanovic GS, Pavlovic AN, Pecev-Marinkovic ET (2015): Elemental composition of edible nuts: fast optimization and validation procedure of an ICP-OES method. Journal of the Science and Food and Agriculture, 95, 2271–2278.

Vijayakumari P, Siddhuraju P, Pugalenthi M, Janardhanan K (1998): Effect of soaking and heat processing on the levels of antinutrients and digestible proteins in seeds of Vigna aconitifolia and Vigna sinensis. Food Chemistry 63, 259–264.

Wang N, Lewis MJ, Brennan JG, Westby A (1997): Effect of processing methods on nutrients and anti-nutritional factors in cowpea. Food Chemi 58, 59–68.

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