CONTENT OF BIOGENIC ELEMENTS INDUCED BY THE INFLUENCE OF THE INOCULANT IN SELECTED CHICKPEA SLOVAK VARIETIES

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ABSTRACT

In the study, we focused on the evaluation of the content of biogenic elements inducted by the addition of inoculant in six Slovak chickpea varieties. We analyzed Cu, Zn, Mn, Fe, Cr, Ni, Co, K, Na, Ca, Mg and P. We evaluated two variants from each variety control variant (A) and variant with inoculant (B). Seed inoculation was provided by the inoculant Rizobin. We used for analyzed 1 g from dry seeds from each genotype. We mineralized the samples on a MARS X-press. The result was atomic absorption spectrometry using VARIAN DUO 240FS / 240Z.

The average Cu content in A control variant was 5.95 mg.kg⁻¹ was reduced to 5.53 mg.kg⁻¹ by the addition of inoculant. For Zn, we also recorded a reduction by the addition of inoculant from 25.43 mg.kg⁻¹ of variant A to 24.95 mg.kg⁻¹ of B variant. The Mn content was the same in both variants and did not change significantly. We recorded the largest differences in the Fe content. The Fe content was reduced from 50.60 mg.kg⁻¹ variant A to 45.07 mg.kg⁻¹ variant B by adding an inoculant. The content of Cr, Ni and Co did not change significantly with the addition of inoculant. Potassium ranged from 8904.45 mg.kg⁻¹ variant A to 8720 mg.kg⁻¹ B variant. Variant A had detected a higher Na content 84.22 mg.kg⁻¹. The average content of Ca and Mg was reduced by adding the inoculant of B variant. The P content of 1400.88 mg.kg⁻¹ Varient B was reduced in variant A to 1346.53 mg.kg⁻¹.

Keywords: legumes, chickpea, inoculant, biogenic elements, Slovak varieties

INTRODUCTION

Chickpeas (Cicer arietinum L.) is considered one of the oldest legumes and is characterized by high consumption worldwide. It is grown mainly in India, Pakistan, Iran, Ethiopia, Mexico (Raza et al., 2019). It is one of the most cultivated crops in the world (Ghribi et al., 2015). Cultivation is widespread in more than 50 countries, Asia accounts for 90% (Kumar, 2019). It is a one-year-old pulp that is suitable for mild to dry climates, has a high heat tolerance, with sufficient soil moisture, prefers a temperate zone (Wallace et al., 2016, Bulbula, 2018).

We distinguish two types of chickpeas: Kabuli and Desi. The Kabuli type is grown in the Mediterranean. These are large seeds (100-750 mg), which are typical of a round shape, have a smooth beige surface and are grown in America. Their energy value is approximately 565 kcal / 100 g (Bulbula, 2018). Desi is grown mainly in semi-arid terrains, forming small (80-350 mg), charred seeds that have a rough and grooved surface. They are dark colored and have an energy value of 327 kcal / 100 g (Rachwat et al., 2015). Chickpeas are one of the main growing commodities (Raza et al., 2019). The minerals that chickpea plants obtain from the soil environment are arri...
cholesterol (Raza et al., 2019). We rank chickpeas in terms of nutrition as an excellent source of macronutrients, they contain minerals (phosphorus, calcium, magnesium, iron, zinc, potassium, sodium, copper and manganese) and vitamins (vitamin C, thiamine, riboflavin, niacin, pantothenic acid, folate, vitamin B6, choline, vitamin K, vitamin E and vitamin A) and β-carotene (Hostek et al., 2017).

Copper, chromium, iron and zinc are essential micronutrients for human health. They play an important role in human metabolism and their interest is increasing in the context of information on the relationship between trace element status and oxidative diseases (Saris et al., 1994; Fennema, 2000, 2018). Zinc deficiency has also come to the attention of nutritionists, economists and medical scientists. Micronutrient malnutrition appears to be a serious global threat, affecting more than 33% of the world's population (WHO 2012). The global zinc deficiency affects about 1.1 billion people, where pregnant women and children are most at risk. Zinc deficiency results in health disorders such as immune system abnormalities, impaired physical growth and learning, and an increased risk of infections (Gibson 2006; Prasad 2007).

Magnesium, which is an important part of the basic processes of energy production and nucleic acid synthesis, is part of more than 300 enzyme systems (Saris et al. 2000). It is also involved in the regulation of muscle contraction (including cardiac), blood pressure and insulin metabolism, as well as in the synthesis of DNA, RNA and proteins (Gröber et al., 2015).

Sodium is a very important mineral for human health. It maintains the volume of plasma, regulates the water content in the body and ensures the balance of electrolytes. In addition, it is responsible for nerve impulse transmission and normal cell function. Increased sodium in a person's diet can cause high blood pressure. This problem is usually associated with high consumption of sugar and fat, in addition to salt (Elias et al., 2020).

Phosphorus is a basic element of hydroxyapatite, a key inorganic component of bone. It is also essential for many cellular compounds, such as phospholipids, phosphoproteins, nucleic acids, and adenosine triphosphate (ATP) (Arnaud and Sanchez, 1996).

Lipids (4–10%) are also present in small concentrations in chickpeas, unsaturated fatty acids are also represented, especially linoleic (54.7–56.2%), oleic (21.6–22.2%), linolenic (0.5–0.9%), palmitic (18.9–20.4%) and stearic (1.3–1.7%) (Rachwat et al., 2015). In addition, alkaloids, lectins, saponins, phytic acid and trypsin, chymotrypsin and α-amylases are present. (Rachwat et al., 2015, Chen et al., 2014). Finally, chickpeas contain phytochemicals such as phenols, which represent 0.72 to 1.81 mg/g of seed (Rachwat et al., 2015).

RESULTS AND DISCUSSION

In our study, we focused on the content of biogenic elements induced by the addition of inoculant in dried chickpea seeds. From the micro elements we evaluated the content of Cu, Zn, Mn, Fe, Cr, Ni and Co. Comparison of average values of microelement content in selected chickpea genotypes in control A variant and with the inoculant are given in Graph 1.

Graph 1

Comparison of average values of microelement content in selected chickpea (Cicer arietinum L.) genotypes in both variants A and B in mg.kg⁻¹.

- The copper content in control A variant ranged from 5.40 mg.kg⁻¹ (Slovak) to 6.60 mg.kg⁻¹ (Businsky).
- The addition of inoculant B variant increased the copper content by 3.45% (Alfa), 1.85% (Slovak).
- In other varieties the copper content decreased by adding the inoculant (Table 2,3).

According to Özcan et al. (2013) measured in seeds Zn contents of 31.32 mg.kg⁻¹ (C. arietinum L.). Acceptable Zn intake will ensure normal reproduction and functioning organism (Holtz and Brown 2004). The highest zinc content in control variant A was recorded in the variety Businsky 26.20 mg.kg⁻¹, the variety Beta 24.70 mg.kg⁻¹ contained the least Zn. By adding the inoculant the zinc content was lower in all varieties except the variety Slovak, where the zinc content was higher by 3.47% (Table 2,3).

Manganese (Mn) is an important component of the synthesis and activation of several enzymes. It is also involved in the regulation of glucose and lipid metabolism in humans. (Li and Yang, 2018). We measured Mn from 17.10 mg.kg⁻¹ (Beta) to 21.10 mg.kg⁻¹ (Businsky). The highest increase by adding the inoculant was found in the variety Maskovsky Bagovec (7.85%). We found that the content of Zn and Mn in the monitored samples in A and B variants, based on a statistical comparison from the F-test, the value of P is less than 0.05, there is a statistically significant difference between the averages of these two samples at the 95.0% confidence level (Table 4).

By statistical evaluation based on the comparison of two samples using t-test, W-test and K-S test, there is no statistically significant difference between the averages of these two samples at the level of 95.0%, confidence level (Table 3).
Legumes generally have a high iron and mineral content (Sundberg, 2002). Fe concentrations in chickpeas have been found to range from 3 to 14.3 ppm (Wood and Grusak, 2007), but due to the presence of naturally occurring inhibitors, only a small amount is bioavailable (Hemalatha et al., 2007). In our samples the iron content ranged from 44.50 mg.kg⁻¹ (Beta) to 58.90 mg.kg⁻¹ (Businsky) in A variant. Due to the addition of the inoculant, all varieties had a reduced Fe about content of 1.80% to 21.22% (Table 2.3). Statistical comparison of the Fe content in A and B variants we found, that since the P-value is less than 0.05 in all tests, there is a statistically significant difference between the averages of these two samples at the level of 95.0% confidence level (Table 4). The increased cobalt content in all variants was increased by the addition of an inoculant. It has an important position in human structure and metabolism. The lowest sodium content in the Alfa variety was 68.80 mg.kg⁻¹ (Slovak). In variety Slovak, the Ca content was 773.80 mg.kg⁻¹ (Slovak). The Ca content decreased by 26.10% due to the inoculant.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Content of selected microelements in chickpea (Cicer arietinum L.) in control A variant (mg.kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea varieties</td>
<td>Cu</td>
</tr>
<tr>
<td>Krajova z Kralovej</td>
<td>5.90</td>
</tr>
<tr>
<td>Maskovsky Bagovec</td>
<td>6.10</td>
</tr>
<tr>
<td>Businsky</td>
<td>6.60</td>
</tr>
<tr>
<td>Slovak</td>
<td>5.40</td>
</tr>
<tr>
<td>Beta</td>
<td>5.90</td>
</tr>
<tr>
<td>Alfa</td>
<td>5.80</td>
</tr>
</tbody>
</table>

Minerals from the soil environment are transported to chickpea plants and get into the seeds (Grusak & DelPenna, 1999). The main minerals that a plant provides to humans (e.g., Na, I, Se and Cr), may not be important to plants. Many of these essential minerals provide chickpea seeds to humans. From macro elements we focused in our experiment on content of K, Na, Ca, Mg and P in selected varieties of chickpea (Graph 2) in control A variant and variant with inoculant B.

<table>
<thead>
<tr>
<th>Element</th>
<th>Chickpea A (average ± SD)</th>
<th>Chickpea B (average ± SD)</th>
<th>t-test (P-value)</th>
<th>F-test (P-value)</th>
<th>W-test (P-value)</th>
<th>K-S-test (P-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>5.950 ± 0.394</td>
<td>5.533 ± 0.463</td>
<td>0.001</td>
<td>0.469</td>
<td>0.004</td>
<td>0.031</td>
</tr>
<tr>
<td>Zn</td>
<td>25.433 ± 0.585</td>
<td>24.95 ± 1.636</td>
<td>0.189</td>
<td>0.012</td>
<td>0.397</td>
<td>0.259</td>
</tr>
<tr>
<td>Mn</td>
<td>19.350 ± 1.229</td>
<td>18.630 ± 3.313</td>
<td>0.381</td>
<td>0.000</td>
<td>0.649</td>
<td>0.259</td>
</tr>
<tr>
<td>Fe</td>
<td>50.600 ± 5.154</td>
<td>45.067 ± 2.166</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Cr</td>
<td>0.600 ± 0.167</td>
<td>0.616 ± 0.147</td>
<td>0.719</td>
<td>0.502</td>
<td>0.812</td>
<td>0.893</td>
</tr>
<tr>
<td>Ni</td>
<td>0.700 ± 0.200</td>
<td>0.884 ± 0.271</td>
<td>0.009</td>
<td>0.320</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Co</td>
<td>0.333 ± 0.098</td>
<td>0.418 ± 0.147</td>
<td>0.014</td>
<td>0.009</td>
<td>0.057</td>
<td>0.259</td>
</tr>
</tbody>
</table>

1 t-test to compare means; 2 F-test to compare standard deviations; 3 Mann-Whitney (Wilcoxon) W-test to compare medians; 4 Kolmogorov-Smirnov test to compare the distributions of the two samples.

The major and most abundant cation in the intracellular fluid is potassium. It plays an important role in maintaining cell function. Its value determines through the cell membrane the potential of the cell membrane, which is ensured by the ubiquitous ion channel Na-K (Na + - K +) ATPase pump (Stone et al., 2016). Potassium content varied from 8198.70 mg.kg⁻¹ (Slovak) to 9221.20 mg.kg⁻¹ (Alfa) in control A variant. The addition of inoculant reduced the content of potassium in all varieties except Beta, where the content of potassium was 0.45% higher.

Graph 2 Comparison of average values of macroelement content in selected chickpea (Cicer arietinum L.) genotypes in both variants A and B in mg.kg⁻¹.

Of the macroelements, chickpeas are a rich source of phosphorus and magnesium. The lowest magnesium content was found in the variety Krajova z Kralovej 949.10 mg.kg⁻¹, the highest in the variety Slovak 1061.00 mg.kg⁻¹ in control A variant. The addition of inoculant reduced the magnesium content in all varieties from 0.60% (Beta) to 12.58% (Slovak). A statistically significant difference between chickpea A and chickpea B was proven for potassium (W-test, K-test), magnesium (W-test) and calcium (t-test, W-test) P<0.05.

The lowest sodium content in the Alfa variety was 68.80 mg.kg⁻¹, the highest in the Maskovsky Bagovec variety was 103.20 mg.kg⁻¹ in control A variant. The effect of inoculant in B variant reduced the sodium content in all varieties monitored.

The last element monitored was phosphorus. Its content in control A variant ranged from 1155.10 mg.kg⁻¹ (Slovak) to 1522.10 mg.kg⁻¹ (Maskovsky Bagovec). Addition of inoculant increased the content by 16.33% (Businsky). It has an important position in human structure and metabolism. By statistical evaluation of...
the P content in A and B variants based on the comparison of two samples using t-test, W-test, F-test and K-S test, there is no statistically significant difference between the averages of these two samples at the level of 95.0% confidence level (Table 5).

Table 5: Measured values of macro-macro elements in selected chickpea (Cicer arietinum L.) varieties in the monitored variants A and B with P-values derived from t-test, W-test, F-test and K-S Test.

<table>
<thead>
<tr>
<th>Element</th>
<th>Chickpea A (average ± SD)</th>
<th>Chickpea B (average ± SD)</th>
<th>t-test (P-value)</th>
<th>F-test (P-value)</th>
<th>W-test (P-value)</th>
<th>K-S test (P-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>8904.450 ± 341.971</td>
<td>8720.00± 308.144</td>
<td>0.0557</td>
<td>0.621</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Na</td>
<td>84.216 ± 12.025</td>
<td>50.217 ± 9.125</td>
<td>0.000</td>
<td>0.193</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Ca</td>
<td>651.233 ± 77.962</td>
<td>601.883 ± 58.499</td>
<td>0.017</td>
<td>0.176</td>
<td>0.021</td>
<td>0.139</td>
</tr>
<tr>
<td>Mg</td>
<td>1007.180 ± 43.059</td>
<td>990.400 ± 46.643</td>
<td>0.202</td>
<td>0.704</td>
<td>0.049</td>
<td>0.139</td>
</tr>
<tr>
<td>P</td>
<td>1346.530 ± 135.657</td>
<td>1400.880 ± 171.465</td>
<td>0.229</td>
<td>0.268</td>
<td>0.208</td>
<td>0.005</td>
</tr>
</tbody>
</table>

1 t-test to compare means; 2 F-test to compare standard deviations; 3 Mann-Whitney (Wilcoxon) W-test to compare medians; 4 Kolmogorov-Smirnov test to compare the distributions of the two samples.

CONCLUSION

In our study, we focused on the effect of inoculation on the content of biogenic elements in the seeds of selected Slovak chickpea genotypes. We evaluated Cu, Zn, Mn, Fe, Cr, Ni and Co from macro elements and K, Na, Ca, Mg and P from macro elements. The results presented in Table 5 show that inoculation did not significantly affect the contents of individual elements. To determine whether the differences in elemental contents of chickpeas are due to the location, the harvest period and the nutritional status of the plants and various other factors that affect the mineral content.

We found that inoculation did not significantly affect the content of individual elements. A statistically significant difference was reflected in the content of Fe on the comparison of two samples using t-test, W-test, F-test and K-S test. Conversely, statistical evaluation of the P content in variants A and B based on the comparison of two samples using t-test, W-test, F-test and KS test, we found that there is no demonstrable difference between the averages of these two samples at the level of 95.0% level of confidence.

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