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Determination of the macroelement content of breads fortified with different spices and their contribution to the nutrient reference value

Keywords: spices, bread, fortification, macroelement, nutrient reference value (NRV)

1. SUMMARY

Many studies are published on food fortification, as the production, testing and consumption of functional foods has become a central issue these days. Bread is one of our important staple foods, and we also regularly eat various spices. Bread may also contain spices. In the course of our work, bread recipes containing different spices in different quantities were developed. In this study, the macroelement content of seven spices (basil, dill, oregano, caraway, chives, rosemary and garlic granules) and 42 fortified breads were determined using an inductively coupled plasma optical emission spectrometer (ICP-OES), and their contribution to the nutrient reference value (NRV) was calculated. Based on the measured concentrations, higher element contents were measured in the spices used by us compared to the values of other studies. Outstanding results values were determined in basil, dill, oregano and chives.

In the case of breads, the calcium, potassium and magnesium content of the products made with the above-mentioned spices was higher than the data found in the literature. Taking into account the results, it was possible to produce macroelement-containing products that contribute to the body's daily macroelement needs more than usual.

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2. Introduction

Conscious food consumers have recognized and accepted that the consumption of "healthier" foods can prevent certain diseases. (The term "healthier" food can be misleading, because according to EU laws, "unhealthy" food cannot be placed on the market. In the present case, I accept that this term represents a comparative. The Ed.) In addition to researchers, industry also strives to develop and produce „healthier" foods **[1, 2]**. Bread and bakery products play an important role in the human diet. Wheat bread is generally an efficient source of energy and contains irreplaceable nutrients. The fortification of these products with functional components is widespread in order to improve health protection **[3].** Examples of such components are spices and herbs **[1, 2]**, as well as byproducts of cereals, pseudo-cereals, vegetable or fruit products **[3]**.

Several publications have reported on the fortification of breads with various substances, which was also detailed by Varga-Kántor et al. **[4]**.

Fortified breads are more valuable than plain bread from a nutritional physiology point of view, as they contain ingredients that have a beneficial effect on health. Spices and herbs are examples of this.

These plants, which are equally important in the pharmaceutical industry and in gastronomy, have been used by mankind for a long time. They have a strong, concentrated smell and taste, so consuming large amounts of herbs may even have an adverse sensory effect **[5]**. The spices we used and their active ingredients are applied in the treatment of several diseases. Many scientific books and studies have reported on their use in this area.

A detailed description of the spices used and measured in our experimental program can be found in the following sources: Pushpagadan **[6]**, Kurian **[7]**, Peter **[8]**, Charles **[9]**, Gupta **[10]**, Kintzios **[11]**, Chen **[12]**, Sasikumar **[13]**, Pandey **[14]**. These works describe the origin of the spices, their physiological effects on humans, and their history.

Spices that contain compounds with potent antioxidant and disease-preventing effects have a high element content, which is important for a balanced diet and lifestyle. ***Table 1*** contains the measurement results of other authors for these parameters.

Table 1. Spices' element content is other studies (mg/kg)

Spices	Ca	K	Mg	Na	P	S
Basil	22600-24800[15]; 12363[16]; 15759[18]; 10481-10712[19]; 22400[21]	24811[16]; 27669[18]; 8708-8726 [19]; 26300[21]	6150-6810[15]; 5738[16]; 3130[18]; 2193-2197[19]; 7110[21]	20.7[16]; 2894[18]; 78.9-83.1[19]; 760[21]	4960[16]; 8259[18]; 2740[21]	1923[16]
Dill	11750[16]; 17800[17]; 17840 [21]	35723[16]; 72000[17]; 33080[21]	4628[16]; 19940[17]; 4510[21]	477[16]; 4800[17]; 2080[21]	1745[16]; 14600[17]; 5430[21]	5699[16]; 24 [17]
Oregano	10600-11200[15]; 10473[16];15970 [21]	19625[16]; 12600[21]	1910-2150[15]; 3268[16]; 2700[21]	21.2[16]; 250[21]	1609[16]; 1480[21]	1947[16]
Caraway	6781[16]; 6890[21]	5343[16]; 13510[21]	2313[16]; 2580[21]	4.74[16]; 170[21]	1853[16]; 5680[21]	738[16]
Chives	9260-9490[16]; 8130 [21]	26900[21]	2960-3260[15]; 6400[21]	700[21]	5180[21]	no data
Rosemary	10899[16]; 8605[18]; 8309-8417[19]; 12800[21]	9356[16]; 11116[18]; 5620-5740[19]; 9550[21]	3688[16]; 2407[18] 869-887[19]; 2200[21]	25.6[16]; 4893[18]; 298-303[19]; 500[21]	418[16]; 8205[18]; 700[21]	1030[16]
Garlic granules	668[19]; 790[20]	11957[20]; 11930[21]	848[20]; 770[21]	571[20]; 600[21]	4091[20]; 4140[21]	6906[20]

While Barin et al. **[15]** and the USDA **[21]** measured a calcium concentration of 22,000 mg/kg in basil, the values reported by other authors were between 10,000 and 15,000 mg/kg. In the case of dill, the results of Rahmatollah and Mahbobeh **[17]** and the USDA **[21]** were similar, while lower concentrations were measured by Özcan **[16]**. The USDA database **[21]** had a higher calcium content for oregano than Barin et al. **[15]** and Öczan **[16]**. The calcium content of caraway was similar **[16, 21]**, while in the case of chives, there was a 1,000 mg/kg difference **[15, 21]**. When looking at rosemary, the results show that two authors obtained similar results of about 8,000 mg/kg **[18, 19]**, but in the other two cases, higher calcium contents were determined **[16, 21]**. In the case of garlic granules, there was no significant difference between the measured concentrations **[20, 21]**.

In the case of potassium content, the highest concentration was measured in dill. Potassium contents close to 34,000 mg/kg were determined by two authors **[16, 21]**, but the values of Rahmatollah and Mahbobeh **[17]** were twice as high. In the case of basil, concentrations above 24,000 mg/kg were measured by three authors **[16, 18, 21]**, however, Ozygit et al. **[19]** only measured a potassium content of 8,000 mg/kg. In the case of oregano, the measured values of this parameter were between 12,000 and 19,000 mg/kg. In the case of caraway, the results obtained differed significantly. The USDA database **[21]** described a potassium content of more than 26,000 mg/kg in chives. The potassium content of rosemary was similar in two cases **[16, 21]**. Ozygit et al. **[19]** measured a lower value than this, while the value measured by Özcan **[16]** was approximately 2,000 mg/kg higher. There was no significant difference in the results of garlic granules.

Looking at the magnesium content results, there were significant differences for all spices between the concentrations measured and published by the researchers. The determined values were in the order of thousands, with the exception of garlic granules.

A similar trend can be observed for the sodium content, as the measured concentrations differ significantly in the various studies.

In the case of phosphorus, similar values were obtained by the authors for oregano and garlic granules. In the case of the other herbs, there were significant differences between the results of the authors, often in the order of thousands.

Regarding the sulfur content of the spices, it can be seen that very different concentrations were determined in dill, and very high values were obtained for the garlic granules.

3. Materials and methods

3.1. Preparation of the breads

In this study, the macroelement content of seven dried spices (basil, dill, oregano, caraway, chives, rosemary and garlic granules) and 42 fortified breads was determined.

The raw materials for the products were purchased in a supermarket in Debrecen. After the analysis of the spices, the breads were prepared based on the recipe of Varga-Kántor et al. **[4]** and Kántor et al. **[20]**.

These samples contained different concentrations of dried spices (0, 2, 4, 6, 8, 10 and 12 g). The additional ingredients were wheat flour (BL 55, 500 g), 10% vinegar (8 g), sunflower oil (44 g), salt (5 g), granulated sugar (5 g), yeast (30 g), milk (2.8% fat, 150 ml) and 25 °C water (100 ml). The ingredients were stored at room temperature, in their original packaging, in the dark or in a refrigerator until the products were prepared. After kneading, the leavening time was 1 hour at room temperature. The next step was the shaping of the loaves, followed by resting for 10 minutes. The breads were baked in a convection oven at 210 ºC and 95% humidity for 15 minutes (RXB 606, convection oven, Budapest, Hungary). After baking, the products were left in the oven for 6 minutes.

3.2. Determination of element content

In the case of spices, the samples purchased in the store were not dried, but the breads were dried according to standard MSZ 20501-1 **[22]**. Sample preparation was carried out based on the method of Kovács et al. **[23]**. After measuring the bread into a digestion tube, 10 ml of nitric acid (69% v/v; VWR International Ltd., Radnor, USA) was added to the sample and it was left to stand overnight. Predigestion was carried out at 60 °C for 30 minutes. After cooling, before the main digestion, 3 ml of hydrogen peroxide (30% v/v; VWR International Ltd., Radnor, USA) was used, and then the sample was kept at 120 °C for 90 minutes. After cooling, it was diluted with high purity water (Millipore SAS, Molsheim, France) and the mixture was filtered on filter paper (388, Sartorius Stedim Biotech SA, Gottingen, Germany). The element content was determined using an ICP-OES (Inductively coupled plasma optical emission spectrometer, Thermo Scientific iCAP 6300, Cambridge, UK) instrument. The wavelengths used were 315.8 nm (Ca), 769.8 nm (K), 280.2 nm (Mg), 818.3 nm (Na), 185.9 nm (P) and 180.7 nm (S).

3.3. Statistical analysis

To determine the mean, standard deviation and statistically verifiable differences, one-factor analysis of variance (Tukey and Dunnett's T3 test) was used with SPSS statistical software (version 13; SPSS Inc. Chicago, Illinois, USA). Measurements were carried out in triplicate.

3.4. Calculation of the daily intake value from the nutrient reference value (NRV)

NRV values are contained in Regulation (EU) No 1169/2011 of the European Parliament and of the Council **[24]** and the EFSA scientific bulletin **[25]**. Data are presented as a percentage for 100 g of product, which means the consumption of approximately 1.5 slices of bread.

NRV (%) = (element content of the bread/daily reference intake) x100

In the case of sodium, the daily reference intake is 2,000 mg **[25]**, while no relevant data were found for sulfur.

4. Results and evaluation

4.1. Measurement results of the element content of the spices

The results of the macroelement content measurements of the herbs examined by us are presented in ***Table 2***. The values are given on an as received basis.

The highest calcium concentration was measured in the case of basil, followed by chives. The measured values were similar in dill and oregano. A value of more than 10,000 mg/kg was measured in rosemary, while in the case of caraway, the concentration was higher than 6,000 mg/kg. The lowest calcium content was measured in garlic granules.

Table 2. Element content of the spices for original matter (mg/kg)

Spices	Ca	K	Mg	Na	P	S
Basil	21389±871	26862±590	7650±372	695±18	3816±88	2596±77
Dill	15033±482	21583±942	3595±95	8508±213	3286±22	7564±74
Oregano	14171±220	9071±60	2086±3	62.2±5.4	1400±0	1545±5
Caraway	6225±1	12416±22	2987±0	23.4±0.1	6604±21	1794±11
Chives	17717±124	16718±78	1972±27	36.3±7.6	3224±13	3686±93
Rosemary	10491±99	7551±337	2368±66	97.5±16.8	531±18	1213±6
Garlic granules	411±17	13056±329	758±28	422±14	4265±60	7137±314

In the case of the potassium content, basil and dill exhibited outstanding values. In caraway, chives and garlic granules, the concentrations were above 10,000 mg/kg. The herbs oregano and rosemary showed the lowest values among the plants analyzed.

The highest magnesium content was measured in basil, which had twice the concentration of dill, which also had a high value compared to the other samples tested. The values for oregano, caraway, chives and rosemary were between 2,000 and 3,000 mg/kg. The lowest magnesium content was found in garlic granules.

An outstanding sodium content was measured in dill, but the concentrations were very low on the other samples. Values higher than 100 mg/kg were obtained for the basil and garlic granule samples. In the other cases, the measured values were below 100 mg/kg.

In case of the phosphorus content, the concentration in caraway was the highest, followed by the garlic granules. Values between 3,000 and 4,000 mg/kg were measured for basil, dill and chives. Rosemary had the lowest concentration.

During the determination of the sulfur content, concentrations of more than 1,000 mg/kg were measured in each sample. Similarly outstanding values were obtained for dill and garlic granules, followed by chives with a concentration of more than 3,000 mg/kg. For the other spices, with the exception of basil, sulfur contents between 1,000 and 2,000 mg/kg were detected.

Comparing the results of ***Table 1*** with the concentration measured by us, it can be stated that in the course of our analyses, higher values were obtained for the calcium content of chives and the sulfur content of dill and caraway, while lower values were measured for the potassium content of dill, oregano and chives and the phosphorus content of chives. However, from the measured concentrations it can be concluded that the results obtained are similar to the values mentioned in the other studies, except for the data regarding the sodium content. In this case, results that are significantly different from the literature data can be seen.

4.2. Measurements results of the breads fortified with spices

The breads were prepared based on a predetermined recipe **[4, 20]**, and samples without spices were also prepared. Based on the results, it was determined that the measured parameters of the control breads were similar to the literature data (Ca: 476; K: 2,200; Mg: 260; Na: 2,585; P: 1,478 and S: 1,008 mg/kg **[4]**; Ca: 510; K: 2,418; Mg: 285; Na: 3,180; P: 1,512 and S: 948 mg/kg **[20]**), except for the sodium content.

The results are reported on a dry matter basis (***Tables 3, 4 and 5***). In the tables, significant deviations from the control samples are marked with the letter „**a**" in each column.

4.2.1. Calcium content results

The calcium contents of the fortified breads are presented in ***Table 3***. In most cases, the addition of spices increased the element content of the fortified breads. The biggest increase was experienced in the case of basil breads. In this case, the difference compared to the control sample was more than 500 mg/kg. Breads containing dill, chives or rosemary showed a difference of about 300 mg/kg between the control bread and the breads fortified with 12 g of spices. The additional value of breads fortified with oregano and caraway was smaller, around 100-200 mg/kg.

Although the calcium content of oregano exceeded 10,000 mg/kg, the increase experience in fortified breads was not as large as when using spices with similar calcium content.

The lowest calcium content was determined in the bread containing 12 g of garlic granules. The other samples showed significant differences compared to the control sample.

4.2.2. Potassium content results

The potassium contents of the samples analyzed are also shown in ***Table 3***. Based on the results, it appears that the addition of basil and dill increased the potassium concentration of the breads the most. In the case of the breads fortified with 12 g of caraway, a difference of about 300 mg/kg was found, compared to the control sample. In the other cases, the difference was barely more than 200 mg/kg.

In terms of potassium content, the greatest increase was exhibited by the breads with basil and dill, followed by the product samples with caraway, oregano and garlic granules. In all cases, the lowest values were measured in breads with rosemary and chives. This difference is probably due to the difference already present in the control breads.

Table 3. Calcium and potassium content of the enriched breads (mg/kg) and their NRVs (%) for 100 g products (p=0,01%, a-the marking shows the significant differences from the control per column)

Spice content (g)	Basil		Dill		Oregano		Caraway	
	Ca (mg/kg)	K (mg/kg)	Ca (mg/kg)	K (mg/kg)	Ca (mg/kg)	K (mg/kg)	Ca (mg/kg)	K (mg/kg)
0	452±37	2229±56	469±27	2190±67	461±12	2232±40	433±14	2290±57
NRV (%)	*5.65*	*11.1*	*5.86*	*10.9*	*5.76*	*11.2*	*5.41*	*11.5*
2	554±21	2293±48	515±7	2311±6	488±18	2201±64	447±10	2335±35
NRV (%)	*6.93*	*11.5*	*6.44*	*11.6*	*6.10*	*11.0*	*5.59*	*11.7*
4	666±9**a**	2488±9**a**	566±20**a**	2451±54**a**	555±5	2363±42	475±18	2371±70
NRV (%)	*8.33*	*12.4*	*7.08*	*12.3*	*6.94*	*11.8*	*5.94*	*11.8*
6	740±37**a**	2586±55**a**	602±6**a**	2449±44**a**	653±52**a**	2413±25**a**	520±24**a**	2577±53**a**
NRV (%)	*9.25*	*12.9*	*7.53*	*12.2*	*8.16*	*12.1*	*6.50*	*12.9*
8	828±36**a**	2751±89**a**	700±20**a**	2692±36**a**	666±42**a**	2374±17	520±7**a**	2532±53**a**
NRV (%)	*10.4*	*13.8*	*8.75*	*13.5*	*8.33*	*11.9*	*6.50*	*12.7*
10	903±23**a**	2859±32**a**	747±31**a**	2762±46**a**	748±50**a**	2469±80**a**	547±33**a**	2543±130**a**
NRV (%)	*11.3*	*14.3*	*9.34*	*13.8*	*9.35*	*12.3*	*6.84*	*12.7*
12	1008±41**a**	2856±68**a**	787±33**a**	2872±60**a**	714±24**a**	2456±3**a**	555±24**a**	2614±37**a**
NRV (%)	*12.6*	*14.3*	*9.84*	*14.4*	*8.93*	*12.3*	*6.94*	*13.1*

Table 3. continued

Spice content (g)	Chives		Rosemary		Garlic granules	
	Ca (mg/kg)	K (mg/kg)	Ca (mg/kg)	K (mg/kg)	Ca (mg/kg)	K (mg/kg)
0	497±7	1976±14	519±17	1980±40	498±5	2144±24
NRV (%)	*6.21*	*9.89*	*6.49*	*9.90*	*6.23*	*10.7*
2	555±15**a**	1991±26	597±6	2069±37	493±8	2181±38
NRV (%)	*6.94*	*9.95*	*7.46*	*10.3*	*6.16*	*10.9*
4	595±14**a**	2058±36	628±10**a**	2076±12	483±3	2206±35
NRV (%)	*7.44*	*10.3*	*7.85*	*10.4*	*6.04*	*11.0*
6	660±13**a**	2125±36**a**	680±15**a**	2145±54**a**	474±2**a**	2217±16
NRV (%)	*8.25*	*10.6*	*8.50*	*10.7*	*5.93*	*11.1*
8	720±6**a**	2141±24**a**	713±41**a**	2149±40**a**	462±9**a**	2232±8
NRV (%)	*9.00*	*10.7*	*8.91*	*10.7*	*5.78*	*11.2*
10	745±12**a**	2132±10**a**	773±9**a**	2177±45**a**	481±9	2389±51**a**
NRV (%)	*9.31*	*10.7*	*9.66*	*10.8*	*6.01*	*11.9*
12	799±12**a**	2196±23**a**	826±47**a**	2211±28**a**	454±2**a**	2367±39**a**
NRV (%)	*9.99*	*11.0*	*10.33*	*11.1*	*5.68*	*11.8*

4.2.3. Magnesium content results

Data on the magnesium content of the breads are presented in ***Table 4***. In the spices, the highest values were measured in the case of basil and dill, which affected the magnesium content of the breads. When examining the samples, the highest magnesium content was determined in the product fortified with basil. This was the largest difference (200 mg/kg) between the control bread and the a sample containing 12 g of spice. This result was followed by breads fortified with dill. Products with caraway and rosemary showed a similar trend, with a maximum difference of 60 mg/kg between the sample containing the most spice and the control bread. In the case of breads with oregano, the increase was 40 mg/kg in the bread containing the most spice compared to the control product. For those spices where the magnesium content was below 2,000 mg/kg, there was no significant difference in the fortified breads. When looking at samples with the same amount of spices, the highest values were measured in the basil breads in all cases. The lowest concentrations were detected in breads with garlic granules and chives.

Table 4. Magnesium and sodium content of the enriched breads (mg/kg) and their NRVs (%) for 100 g products (p=0,01%, a-the marking shows the significant differences from the control per column)

Spice content (g)	Basil		Dill		Oregano		Caraway	
	Mg (mg/kg)	Na (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Mg (mg/kg)	Na (mg/kg)
0	254±15	2663±78	264±12	2698±108	271±4	2497±45	267±4	2483±29
NRV (%)	*6.77*	*13.3*	*7.04*	*13.5*	*7.23*	*12.5*	*7.12*	*12.4*
2	285±4	2612±18	274±1	2670±11	267±5	2443±51	278±3	2391±33
NRV (%)	*7.60*	*13.1*	*7.31*	*13.4*	*7.12*	*12.2*	*7.41*	*11.9*
4	327±4**a**	2810±21	290±8	2721±47	292±5	2450±44	289±7	2439±57
NRV (%)	*8.72*	*14.1*	*7.73*	*13.6*	*7.78*	*12.3*	*7.71*	*12.2*
6	352±12**a**	2713±61	293±3	2738±48	308±9**a**	2440±32	314±11**a**	2507±95
NRV (%)	*9.38*	*13.6*	*7.81*	*13.7*	*8.21*	*12.2*	*8.37*	*12.5*
8	387±22**a**	2781±110	322±9**a**	2884±65	303±6**a**	2379±32	312±3**a**	2458±44
NRV (%)	*10.3*	*13.9*	*8.59*	*14.4*	*8.08*	*11.9*	*8.32*	*12.3*
10	414±4**a**	2813±43	327±9**a**	2887±51	319±13**a**	2412±73	320±17**a**	2382±123
NRV (%)	*11.0*	*14.1*	*8.72*	*14.4*	*8.51*	*12.1*	*8.53*	*11.9*
12	444±13**a**	2710±75	339±12**a**	3033±97**a**	309±3**a**	2376±17	328±8**a**	2478±49
NRV (%)	*11.8*	*13.6*	*9.04*	*15.2*	*8.24*	*11.9*	*8.74*	*12.4*

Table 4. continued

Spice content (g)	Chives		Rosemary		Garlic granules	
	Mg (mg/kg)	Na (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Mg (mg/kg)	Na (mg/kg)
0	256±2	2432±13	262±7	2828±46	257±3	2507±51
NRV (%)	*6.82*	*12.2*	*6.99*	*14.1*	*6.85*	*12.5*
2	255±3	2512±57	284±5	3011±59	259±5	2513±51
NRV (%)	*6.80*	*12.6*	*7.57*	*15.1*	*6.91*	*12.6*
4	258±3	2524±23	288±3	3053±40**a**	259±1	2595±38
NRV (%)	*6.88*	*12.6*	*7.68*	*15.3*	*6.91*	*12.9*
6	264±4	2567±64	302±7**a**	3165±74**a**	255±1	2546±11
NRV (%)	*7.04*	*12.8*	*8.05*	*15.8*	*6.80*	*12.7*
8	265±5	2444±39	305±11**a**	3242±25**a**	252±2	2455±11
NRV (%)	*7.07*	*12.2*	*8.13*	*16.2*	*6.72*	*12.3*
10	257±3	2398±18	318±5**a**	3050±75**a**	262±4	2598±73
NRV (%)	*6.85*	*11.9*	*8.48*	*15.3*	*6.99*	*13.0*
12	264±3	2317±43	329±11**a**	3113±68**a**	252±2	2453±23
NRV (%)	*7.04*	*11.6*	*8.77*	*15.6*	*6.72*	*12.3*

4.2.4. Sodium content results

Data on the sodium content of the products prepared can be seen in ***Table 4***. Regarding the samples, the measured values were between 2,400 and 3,100 mg/kg. The sodium content of the spices was low compared to the other macronutrients, except for dill. There was no statistically proven difference in the results of the products with basil, oregano, caraway and garlic granules. In the case of the samples with dill, the reason for the increase was probably the sodium content of the spice, which affected the element content of the final products.

In the case of chives and rosemary, the sodium content of the spices was below 100 mg/kg. Therefore, the decrease in one case and the increase in the other cannot be explained. When considering the same amount of spices, the highest sodium content was measured in breads with rosemary, dill and basil. This tendency was also observed in the case of the control breads. Since the breads were made by hand, it is possible that the distribution of table salt was not uniform in all cases, and this may also cause differences.

Table 5. Phosphorus and sulphur content of the enriched breads (mg/kg) and their NRVs (%) for 100 g products (p=0,01%, a-the marking shows the significant differences from the control per column)

Spice content (g)	**Basil**		**Dill**		**Oregano**		**Caraway**	
	P (mg/kg)	S (mg/kg)	P (mg/kg)	S (mg/kg)	P (mg/kg)	S (mg/kg)	P (mg/kg)	S (mg/kg)
0	1448±65	905±44	1489±34	1049±68	1491±22	987±38	1530±25	1072±5
NRV (%)	*20.7*		*21.3*		*21.3*		*21.9*	
2	1483±27	929±14	1493±2	1010±6	1446±33	963±19	1556±15	1069±6
NRV (%)	*21.2*		*21.3*		*20.7*		*22.2*	
4	1531±8	987±14	1529±30	1034±28	1539±27	1022±31	1585±39	1109±25
NRV (%)	*21.8*		*21.8*		*21.9*		*22.6*	
6	1534±26	989±46	1478±30	1043±40	1582±27	1067±34	1689±32	1169±72
NRV (%)	*21.9*		*21.1*		*22.6*		*24.1*	
8	1554±41	1022±60	1586±32	1128±49	1543±19	1046±28	1655±26**a**	1143±7
NRV (%)	*22.2*		*22.7*		*22.0*		*23.6*	
10	1565±8	1061±22**a**	1561±27	1113±31	1566±48	1086±45	1676±75**a**	1171±60
NRV (%)	*22.4*		*22.3*		*22.4*		*23.9*	
12	1575±51	1060±54**a**	1583±40	1135±53	1518±8	1050±3	1695±33**a**	1157±37
NRV (%)	*22.5*		*22.6*		*21.7*		*24.2*	

Table 5. continued

Spice content (g)	**Chives**		**Rosemary**		**Garlic granules**	
	P (mg/kg)	S (mg/kg)	P (mg/kg)	S (mg/kg)	P (mg/kg)	S (mg/kg)
0	1470±16	977±6	1490±27	947±16	1529±16	988±25
NRV (%)	*21.0*		*21.2*		*21.8*	
2	1440±5	979±9	1554±24	980±24	1552±19	1037±27
NRV (%)	*20.6*		*22.2*		*22.2*	
4	1474±23	993±16	1525±23	978±8	1548±13	1079±29
NRV (%)	*21.1*		*21.8*		*22.1*	
6	1478±16	1020±34	1546±39	1003±31	1548±8	1070±11
NRV (%)	*21.1*		*22.1*		*22.1*	
8	1463±20	1013±26	1513±22	997±17	1547±16	1096±7
NRV (%)	*20.9*		*21.6*		*22.1*	
10	1431±12	993±7	1536±21	1015±24	1613±20	1185±57
NRV (%)	*20.4*		*21.9*		*23.0*	
12	1464±16	1019±24	1521±22	1007±21	1576±21	1164±16
NRV (%)	*20.9*		*21.7*		*22.5*	

4.2.5. Phosphorus content measurement results

The phosphorus content results of the samples are presented in ***Table 5***. Based on the results, the phosphorus content of the breads was similar. In most cases, there was no statistically verifiable difference between the samples. Smaller differences were measured in the products with caraway and garlic granules, which is due to the phosphorus content of the spices. The phosphorus content of these spices exceeded 4,000 mg/kg. For the other spices, concentrations below 4,000 mg/kg were determined in all other cases.

The highest phosphorus content was measured in the products with caraway, followed by breads with dill, garlic granules and basil. The lowest concentration was measured in the products flavored with chives, however, low phosphorus contents were measured in the breads with rosemary and oregano as well.

4.2.6. Sulfur content results

Table 5 shows the sulfur content of the breads. Based on the concentrations obtained, larger differences were measured in the products with basil and garlic granules, and smaller differences were measured in the case of the other fortifications when increasing the amount of spices. Analyzing the spices, the highest sulfur content was determined in dill and garlic granules (more than 7,000 mg/kg), however, even the addition of larger amounts of spices to the breads did not increase the measured concentrations. It can be seen that in the other cases the value of the measured parameter did not increase with the increase in the amount of spices. Minor differences could be observed, but the sulfur content of the spices had no significant effect on the sulfur content of the final products.

Daily intake contribution results calculated from the nutrient reference value (NRV)

Tables 3, 4 and 5 show the daily contribution values for (Ca, K), (Mg, Na) and (P) per 100 g of product, respectively.

In the case of calcium content, the consumption of 100 g of control bread per day covers 5 to 6% of the daily calcium intake. By increasing the amount of spices in the samples, these values also increased. The highest contribution was calculated for the breads with basil, followed by the products with rosemary, dill, and chives.

In the case of the potassium content, the contribution of the control breads was between 10 and 11%. When different amounts of spices were added, a smaller increase was calculated tan in the case of the calcium content. For the breads with the most spices, the increase in daily contribution was even as high as 3% (samples with basil and dill) compared to the control products.

The magnesium content of the control breads is responsible for approximately 7% of the daily magnesium intake. In this case, once again, the most significant differences were observed in the bread with basil. With 12 g of spice, the increase was more than 5% compared to the control sample.

The sodium intake values of all samples were around 12 to 13%. In the case of the products with dill and rosemary, the values were higher.

In terms of phosphorus content, all of the reads covered more than 20% of the daily phosphorus intake. The contribution of the samples with caraway showed a minimal increase. For the breads fortified with 12 g of spices, the increase was around 2% compared to the control products.

5. Conclusions

As the results show, the spices themselves have a high macronutrient content. In terms of calcium, potassium, magnesium and sodium, basil exhibited outstanding values. High values were also measured in dill, chives, oregano and garlic granules.

The content of calcium, potassium and magnesium in fortified breads increased. In the case of calcium, the biggest difference was found in the products with basil. A clear increase was also observed for the other samples as well, except for the application of garlic granules.

Outstanding results were also achieved in terms of the potassium content of products with basil and dill. A difference of almost 600 mg/kg was measured between the control sample and the bread with 12 g of spice.

There was no significant difference in the magnesium content. A greater increase in concentration was only observed for the products with basil.

The samples with rosemary and dill showed a slight increase in sodium content, which can also be observed with the same amount of spices.

No significant differences were found in the phosphorus and sulfur contents; similar values were measured.

Based on the results, the largest daily contribution of macronutrients was provided by the breads with basil, followed by the breads with dill. In the case of the sodium content of the breads, the daily intake contributions of the products with dill and rosemary were the largest.

Overall, it was possible to prepare products whose element content in most cases differed significantly from that of the control breads, so the contribution of the products to the daily reference values also increased.

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