Journal of Agricultural Sciences (Belgrade)
Vol. 67, No. 4, 2022
Pages 415-431

https://doi.org/10.2298/JAS2204415S
UDC: 637.52.041
Original scientific paper

CANNED MEAT PRODUCTS FOR MEMBERS OF THE SERBIAN ARMED FORCES: Na, K, Ca, AND Mg CONTENT AND HEALTH RISKS/BENEFITS

Branislav Đ. Stojanović[1], Zdenka M. Stojanović[2], Sonja S. Marjanović[2], Saša D. Janković[3], Mališa P. Antić[4], Milica R. Balaban[5] and Vesna V. Antić[4*]

[1]Ministry of Defence, Military Health Department,
Crnotravska 17, 11000 Belgrade, Serbia
[2]University of Defence, Military Medical Academy,
Crnotravska 17, 11000 Belgrade, Serbia
[3]Institute of Meat Hygiene and Technology,
Kaćanskog 13, 11000 Belgrade, Serbia
[4]University of Belgrade-Faculty of Agriculture,
Nemanjina 6, 11080 Belgrade-Zemun, Serbia
[5]University of Banja Luka, Faculty of Natural Sciences and Mathematics, Mladena Stojanovića 2, 78000 Banja Luka, Bosnia and Herzegovina

Abstract: Macroelements such as Na, K, Ca, and Mg play a significant physiological role, and their inadequate intake has been linked to severe diseases, such as high blood pressure. Data on risk assessment for human health in Serbia, from the intake of these macroelements through the consumption of canned food, are minimal. Therefore, the content of Na, K, Ca, and Mg in five types of canned meat that members of the Serbian Armed Forces regularly use was examined. Macroelements were determined by inductively coupled plasma mass spectrometry in cans of beef goulash, pork ragout, spam, liver pate, and meatballs in tomato sauce, which were stored from one month to six years. The sodium content was significantly higher than the potassium content in all types of food, so the Na/K ratio below 1, desirable for good health, was not found in any of the analyzed products. Also, a significant number of samples had an unfavorable Ca/Mg ratio above 1. However, due to the low consumption of canned food by members of the Serbian Armed Forces, its contribution to the average daily intake of macroelements is almost negligible. The concentration of macroelements decreased with the shelf life, while a significant source of Ka and Mg, among analyzed ingredients, was ground red pepper.

Key words: macroelements, canned meat products, storage, daily intake, high blood pressure, risk assessment.

[*]Corresponding author: e-mail: vantic@agrif.bg.ac.rs

Introduction

Minerals are nutrients necessary for proper physiological processes and must be taken into the body through food, water, or air. They are divided into macro and microelements. Macroelements (Na, K, Mg, Ca, P, Cl, S) are sometimes required in grams, while microelements (Fe, Zn, Cu, Mn, Se, Cr, Co, Ni, etc.) are usually needed in micrograms for the healthy functioning of the human body. The physiological role of minerals is very diverse. They can play a structural role – as an integral part of bones, teeth, blood, and as structural components of many enzymes (Goff, 2018). Also, minerals participate in synthesizing proteins, hormones, and vitamins. Minerals in lower concentrations have a biological function, while higher concentrations can be harmful to humans (Bogden and Klevay, 2000). The macroelements Na, K, Mg, and Ca are present in the human body in at least 100 mg/(kg BW). The physiological functions of Na and K are multiple: regulation of blood pressure and acid-base balance, muscle contraction, and nerve impulse transmission. Diarrhea, vomiting, or sweating can lead to Na and K loss, which results in hypotension, tachycardia, muscle spasm, and central nervous system failure (EFSA, 2017; National Academies of Sciences, Engineering and Medicine, 2019). Calcium deficiency provokes osteoporosis and can occur due to a poor diet, vitamin D deficiency, and insufficient exposure to sunlight (EFSA Panel on Dietetic Products, 2015a). Symptoms of Mg deficiency are headache, heart problems, muscle pain, etc. (EFSA Panel on Dietetic Products, 2015b).

In contrast, the excessive intake of macroelements can lead to severe adverse health effects. Excessive intake of Na is related to hypertension, while excessive intake of K can lead to weakness, vomiting, and arrhythmias (EFSA Panel on Nutrition, Novel Foods and Food Allergens, 2019; Kogure et al., 2021). High Ca intake is associated with excessive bone calcification, while high Mg intake causes vomiting and diarrhea (EFSA Panel on Dietetic Products, 2015a, 2015b). The European Food Safety Authority (EFSA) has set average requirements (AR) and adequate daily intakes (AI) of macronutrients for adults. AR is an element intake that meets the daily needs of half of the people in a typical healthy population. AI is defined as the average level of element, which is assumed to be sufficient for the population's needs and is used when AR cannot be calculated. Also, the tolerable upper intake level (UL) is defined as the maximum chronic daily intake of minerals estimated to be "unlikely to pose a risk of human side effects". For example, a safe and adequate Na intake is 2000 mg/day, while a K intake is 3500 mg/day. For magnesium, AI amounts to 350 mg/day for males and 300 mg/day for females. On the other hand, the AR for Ca is set at 750 mg/day for the adult population, while UL amounts to 2500 mg/day (EFSA, 2017).

Canned foods have many benefits for consumers, such as convenient use, long shelf life, reasonable price, and short preparation time. The nutritionists do not recommend a daily intake of canned food, as it often contains higher Na content, either for taste or food safety. The trend of increased Na intake, with an abundant consumption of canned food, is evident (Singh and Chandorkar, 2018). Excessive Na and inadequate K intakes are one of the main factors contributing to hypertension and related cardiovascular diseases. Similar to EFSA, the World Health Organization (WHO) has recommended an optimal safe intake of Na of <2000 mg/day (equivalent to 5 g/day of salt) and of K of at least 3510 mg/day for adults (WHO, 2012a, 2012b). Reducing Na in processed foods is part of a public health strategy worldwide, intending to lower blood pressure and prevent cardiovascular disease in the population. Like the Na/K ratio, the relationship between Ca and Mg in the human body is complex (Sukumar et al., 2019). They participate together in regulating heart function, muscle contraction, and nerve conduction.

Determining macroelement concentration in food is necessary for quality assurance and consumer health protection. Therefore, the main goal of this study was to analyze the content of Na, K, Mg, and Ca in various canned meat products, which are in regular use in the Serbian Armed Forces. The macroelements were determined in beef goulash (BG), pork ragout (PR), spam (SP), liver pate (LP), and meatballs in tomato sauce (MB), stored up to six years, and in individual ingredients, used for their production. The influence of the sterilization process on the concentration of Na, K, Mg, and Ca was also investigated. Macroelements were analyzed by the ICP-MS method. The content of macroelements during the storage period was followed, and soldiers' exposure to Na, K, Ca and Mg by consuming canned meat through the daily intake (EDI) and its contribution to adequate daily intake (AI) were assessed.

Material and Methods

Canned meat products

Cylindrical tinplate cans were used for filling the canned meat products: 1) two-piece cans, Ø 73×29.5, for LP of 100 g; 2) three-piece cans, Ø 73/70×43, for SP of 150 g, and 3) three-piece cans, Ø 99/96×63, for BG, PR, and MB of 400 g. The tinplate quality was corresponding to the European standards, with additional requirements related to the thickness of the sheet, the tin's application, and the application and quality of the varnish (Stojanović et al., 2021). The canned food was produced according to military requirements. After filling and sealing, the cans were sterilized by heating for 30 min at 120 °C (LP); 50 min at 118 °C (SP); 70 min at 120° (BG and PR); or for 105 min at 118 °C (MB). Undamaged cans stored for up to 6 years in typical military facilities that provide appropriate conditions (temperature up to max 25 °C and relative humidity up to max 75%) were analyzed.

ICP-MS

Inductively coupled plasma-mass spectrometry (ICP-MS), with the iCapQ mass spectrometer (Thermo Scientific, Germany), was used for macroelement analysis, as described in our previous work (Stojanović et al., 2021). All samples were measured in duplicate, and metal content was presented as an average. The differences between duplicates were ≤ 7.3%. The limit of detection (LOD) was 5.6, 2.2, 3.1, and 0.1 mg/kg for Na, K, Ca, and Mg, respectively, while the limit of quantification (LOQ) was 7.0, 2.9, 3.6, and 0.4 mg/kg, respectively. Quality control was performed in each sample series by analyzing bovine liver as a reference material (NIST 1577c, from the National Institute of Standards and Technology, USA). Solvents and spiked samples were included in each batch of digestion and analysis. The most abundant isotopes were used for quantification, and the concentrations were within the range of the certified values for all isotopes. Average recoveries from spiked samples ranged between 95.4% and 103.0%.

Dietary intake calculations

The estimated daily intake of particular macroelements through all types of canned food was calculated as the sum of the estimates for that macroelement in a particular food type (EFSA, 2011). For example, EDI for Na through all types of food was calculated as:

EDI (Na) = EDI(Na/BG) + EDI(Na/PR) + EDI(Na/SP) + EDI(Na/LP) + EDI(Na/MB).

The EDI of a particular macroelement (ME, for example, Na) and a particular type of canned food (CF, for example, BG) was obtained as:

$$\text{EDI [ME/CF, mg/(kg BW) day]} = \Sigma\ [ME_{conc}\ (mg/kg) \times MC_{conc}\ (mg/kg)]/30,$$

where ME_{conc} is the concentration of a particular macroelement (mg/kg), and MC is the monthly consumption of the particular type of canned food (kg). MC, determined by the nutrition plan, was as follows: 0.160 kg of BG, 0.400 kg of PR, 0.450 kg of SP, 0.300 kg of LP, and 0.400 kg of MB. In emergency circumstances, consumption was twice as high. Once the EDI value for a particular macroelement is calculated, the percentage of contribution to the guideline value can be obtained:

$$\text{Contribution (\%)} = [\text{EDI (mg/day)} / (\text{Guideline value})] \times 100.$$

Statistics

The normality of the data distribution was verified by the Shapiro-Wilk test. Data sets are presented in the form MV ± SD (mean value ± standard deviation) with minimum and maximum in a given group. Mean macroelement concentrations were compared with the corresponding daily intakes (AI) for Na, K, and Mg and the average needs (AR) for Ca, using a one-sample t-test, with probabilities less than 0.01, which was considered statistically significant. All analyses were performed using the *IBM SPSS Statistics 19* software package.

Results and Discussion

Macroelement content in meat products

Canned meat occupies an important place in the diet of members of the Serbian Armed Forces. Canned products are of high quality, with preserved nutritional and energy values, sensory properties, and shelf life of at least four years (Stojanović et al., 2021). The content of macroelements during the storage period from one month (m) to six years (y) is shown in Table 1. A concentration decrease with the storage period was noticed in all products, except MB. The content of macroelements decreased in the following order: Na > K >> Ca ≅ Mg. The content of Na was the highest in all samples. In MB samples, Na and Ca concentrations increased, i.e., Mg and K decreased with storage time, but without statistical significance. The Na content in BG samples dropped from 4025.3 mg/kg (11m) to 2449.9 mg/kg (5y/9m), while in the PR samples, it varied from 4161.3 mg/kg (6m) to 2363.2 mg/kg (5y/9m). The maximum Na value in SP samples was 5022.1 mg/kg (1y/1m), while the minimum was 4049.4 mg/kg (6y). The highest Na content in LP samples was 4001.2 mg/kg (7m), while the lowest was 2667.4 mg/kg (6y). A very similar trend was found for the content of other macroelements (K, Ca, Mg) – a pronounced decreasing trend at more prolonged periods, especially after five years of storage. It can be assumed that there is a certain deposition of macroelements in the form of insoluble compounds on the walls of the cans, which causes a decrease in their concentration during storage. Our finding was in agreement with the recent work of Vafaei et al. (2018), where a significant reduction of Na and Ca was found in canned silver carp samples after 7 years of storage.

In fact, more critical for human health than the individual values of Na, K, Ca, and Mg is the ratio of Na/K and Ca/Mg (Iwahori et al., 2017; Sukumar et al., 2019; Morrissey et al. 2020), which is shown in Table 1. Our diet usually includes too high Na/K and Ca/Mg ratios, which leads to a disturbed balance between intracellular (K, Mg) and extracellular (Na, Ca) electrolytes and causes a state of "low-grade metabolic acidosis" (Carnauba et al., 2017). Diseases associated with this condition are cardiovascular and kidney diseases, stroke, and osteoporosis. The imbalance stems from the habits of > 85% of the population who do not eat enough foods rich in potassium and magnesium (Morrissey et al., 2020). All food types from this work had a Na/K ratio above one, with the highest values in the SP, LP, and MB samples. Also, the Ca/Mg ratio was unfavorable (> 1) in the SP and LP samples, while the BG, PR, and MB samples had a Ca/Mg ratio below 1.

The Shapiro-Wilk test showed a normal distribution of macroelement concentrations relative to the mean value in BG, PR, SP, LP, and MB samples during storage. The mean values of concentrations and their standard deviations in BG, PR, SP, LP, and MB samples during storage are shown in Figure 1 (Na and K) and Figure 2 (Ca and Mg). There was no statistically significant change in the concentration of macroelements concerning the mean value at the significance level of 99% during the storage of analyzed products.

Table 1. The change of macroelement concentration in samples of BG, PR, SP, LP, and MB during the storage period.

Meat product	Storage period (y/m)[a)]	Concentration, mg/kg				Na/K[b)]	Ca/Mg[b)]
		Na	K	Ca	Mg		
Beef goulash (BG)	0/3	3356.8	2427.2	77.9	160.8	1.38	0.48
	0/11	4025.3	2862.2	104.9	194.7	1.40	0.54
	2/2	3303.6	2400.5	88.5	182.4	1.38	0.49
	3/2	3047.7	1894.6	100.4	157.5	1.61	0.64
	4/0	2727.9	2150.3	165.7	231.6	1.27	0.72
	5/1	2762.4	2038.6	104.2	180.2	1.36	0.58
	5/9	2449.9	1855.7	67.7	150.8	1.32	0.49
Pork ragout (PR)	0/3	3371.2	2524.5	64.5	214.5	1.34	0.30
	0/6	4161.3	3103.7	106.3	235.2	1.34	0.45
	2/6	3360.3	2345.9	78.0	152.2	1.43	0.51
	3/2	3097.8	1788.7	81.5	153.2	1.73	0.53
	4/0	3095.8	1795.0	132.6	149.8	1.72	0.89
	5/1	3291.4	1629.6	162.6	147.7	2.02	1.10
	5/9	2363.2	1521.9	88.8	131.2	1.55	0.68
Spam (SP)	0/8	4913.6	2266.0	143.3	152.7	2.17	0.93
	1/1	5022.1	1547.9	155.8	152.7	3.24	1.02
	2/1	4733.3	979.3	315.9	125.1	4.83	2.53
	3/1	4677.5	1053.0	150.2	123.9	4.44	1.21
	4/4	4512.2	1979.9	210.2	139.3	2.28	1,51
	5/0	4284.2	1934.9	256.9	133.3	2.21	1.93
	6/0	4049.4	1228.5	100.8	127.1	3.30	0.79
Liver pate (LP)	0/7	4001.2	1554.2	213.5	121.4	2.57	1.76
	1/1	3983.9	965.9	205.4	120.7	4.12	1.70
	2/6	3274.5	822.3	162.4	84.4	3.98	1.92
	3/0	2872.0	869.9	309.3	116.9	3.30	2.65
	4/4	3657.9	992.3	132.5	94.5	3.69	1.40
	5/0	3558.7	788.8	91.4	79.2	4.51	1.15
	6/0	2667.4	622.3	121.1	80.8	4.29	1.50
Meatballs in tomato sauce (MB)	0/1	4901.2	2370.3	98.0	178.5	2.07	0.54
	1/0	4814.6	2712.3	160.3	190.6	1.78	0.84
	2/8	7122.1	2293.9	87.3	177.7	3.10	0.49
	3/9	5699.1	1992.6	104.1	128.5	2.86	0.81

a) y/m=years/months; b) mg/mg.

The highest mean Na and K concentrations were found in MB samples (5634.2 ± 1068.8 mg/kg and 2342.3 ± 295.7 mg/kg, respectively). The BG and PR samples showed similar mean K concentrations, but significantly lower Na mean values than MB samples: 3096.2 ± 523.0 mg/kg (BG) and 3248.7 ± 531.1 mg/kg (PR). The LP samples possessed a mean Na value in the BG and PR sample ranges, while the mean K concentration of LP samples was the lowest by far, amounting to 945.1 ± 295.2 mg/kg. The SP samples possessed a higher mean K concentration than LP (1569.9 ± 503.1 mg/kg) and showed a significantly high mean Na value (4.598.9 ± 344.2 mg/kg). A lower Na/K ratio is desirable for good health; however, none of the analyzed products were found to have the same. Nevertheless, the mean K content in BG, PR, and MB samples was above 2000 mg/kg, which was pretty high, making these products a rich K source. The mean values of Ca were very similar in BG, PR, and MB samples (≅100 mg/kg), while mean Mg values in the same samples were higher and ranged about 170–180 mg/kg. In contrast to BG, PR, and MB samples, the mean values of Ca in SP and LP samples were higher (190.4 ± 74.9 mg/kg and 176.5 ± 73.4 mg/kg, respectively), compared to mean Mg values, which were 136.3 ± 12.4 mg/kg (SP) and 99.7 ± 19.3.0 mg/kg (LP).

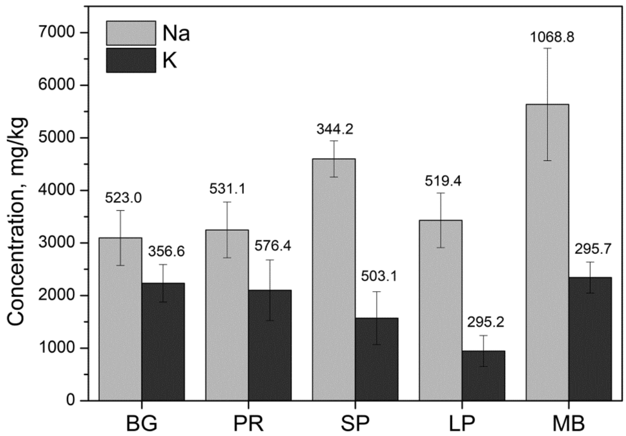

Figure 1. Mean sodium (Na) and potassium (K) concentrations in different kinds of canned meat products (BG – beef goulash; PR – pork ragout; SP – spam; LP – liver pate; MB – meatballs in tomato sauce).

The concentrations of Na, K, Ca, and Mg in the samples from this work were compared with the findings of other authors (Table 2). Other studies show that the results published on canned meat products are minimal compared to fishery products and fresh and processed meat (not canned). Sodium concentrations in samples from other studies were similar to those in our research (Ahuja et al., 2019), even higher in some cases, as in Gillespie et al. (2015), where the highest

Na concentration was 11590 mg/kg. Bilandžić et al. (2021) examined different types of products, including canned meat, where K and Ca concentrations were very similar to those in our work (1932 ± 435 mg/kg and 130 ± 74 mg/kg, respectively). The Mg concentration was slightly higher than the concentration observed in our research (253 ± 313 mg/kg). Djinovic-Stojanovic et al. (2017) found Mg values in canned pork and chicken meat and pate in the range from 117 ± 14.3 mg/kg to 165 ± 34.4 mg/kg, which was almost the same as in our work (99.7 ± 19.3–179.7 ± 27.7 mg/kg).

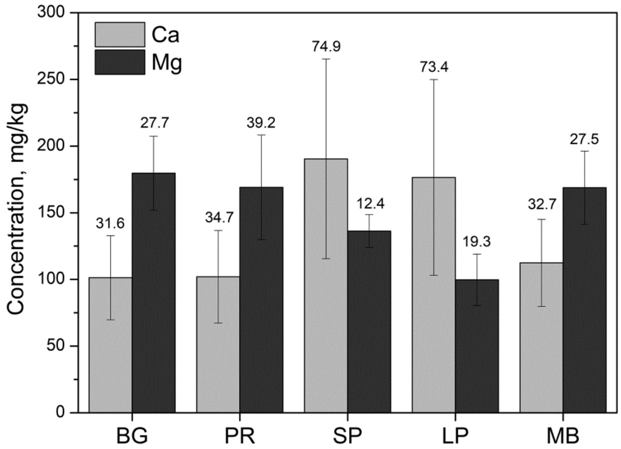

Figure 2. Mean calcium (Ca) and magnesium (Mg) concentrations in different kinds of canned meat products (BG – beef goulash; PR – pork ragout; SP – spam; LP – liver pate; MB – meatballs in tomato sauce).

In canned fishery products, the Na level was mainly between 1600 and 5000 mg/kg (Atanasoff et al., 2013; Rubio et al., 2017; Vafaei et al., 2018; Ahuja et al., 2019; Park et al., 2019). Exceptions were samples of Pacific saury, where a relatively high value of Na, about 7000 mg/kg, was found (Anishchenko et al., 2017). In terms of K, the values in fishery products were very diverse, ranging from about 700 mg/kg (Boufleur et al., 2013) to as much as 7519 mg/kg in dry edible seaweed (Rubio et al., 2017). High values of Ca (2200–4500 mg/kg) were found in samples of Pacific saury (Anishchenko et al., 2017) and dry edible seaweed, which were also extremely rich in Mg (2164 ± 968 mg/kg; Rubio et al., 2017). Non-canned fresh meat, organs, and meat products had significantly lower Na content than canned food (Table 2). Concentrations were below 1000 mg/kg, except in the kidneys, where the Na value was around 1600 mg/kg, and in ham, where the Na values exceeded 1255 mg/kg (Nieto et al., 2018).

Table 2. The data recorded within this study and the results obtained by other authors.

Reference	Macroelements, MV ± SD (mg/kg)			
	Na	K	Ca	Mg
Canned meat products				
Present study	3096.2 ± 523.0– 5634.3 ± 1068.8	945.1 ± 295.2– 2342.3 ± 295.7	101.3 ± 31.6 – 190.4 ± 74.9	99.7 ± 19.3– 179.7 ± 27.7
Gillespie et al., 2015	11590 ± 2270 4720 ± 840	–	–	–
Djinovic-Stojanovic et al., 2017	–	–	–	165 ± 34.4 (pork meat) 117 ± 14.3 (pork pate) 147 ± 32.6 (chicken meat) 142 ± 26.4 (chicken pate)
Ahuja et al., 2019	4490 ± 200	–	–	–
Bilandžić et al., 2021	–	1932 ± 435	130 ± 74	253 ± 313
Canned fishery products				
Boufleur et al., 2013	1596 ± 649– 2635 ± 429	705 ± 105– 1142 ± 213	15.0 ± 5.5– 30.4 ± 15.3	106 ± 23– 202 ± 45
Atanasoff et al., 2013	1950.5 ± 62.9	2447.0 ± 56.0	54.5 ± 1.1	326.9 ± 7.0
Anishchenko et al., 2017	4680.2 ± 433.6 (brand A) 7128.4 ± 565.7 (brand B)	2227.0 ± 72.5 (brand A) 4047.8 ± 150.6 (brand B)	2209.12 ± 431.36 (brand A) 4534.83 ± 785.89 (brand B)	–
Rubio et al., 2017	5044 ± 1760	7519 ± 2692	2205 ± 921	2164 ± 968
Park et al., 2019	2968 ± 366.5– 6041 ± 340.9	672.5 ± 48.14– 3106 ± 65.88	56.55 ± 18.73– 1397 ± 455.0	224.7 ± 7.32– 510.1 ± 47.02
Vafaei et al., 2018	3036.8 ± 137.7– 4004 ± 125.4	–	344.3 ± 62.7– 804.25 ± 40.8	–
Ahuja et al., 2019	2460 ± 580	–	–	–
Meat and processed meat (not canned)				
Tomović et al., 2011	598 ± 141 (muscle) 897 ± 181 (liver)	2940 ± 240 (muscle) 2350 ± 530 (liver)	127 ± 21 (muscle) 209 ± 48 (liver)	276 ± 15 (muscle) 265 ± 44 (liver)
Nikolic et al., 2017	580.44 ± 18.36 (muscle) 956.18 ± 25.77 (liver) 1636.44 ± 38.53 (kidney)	2365.99 ± 32.47 (muscle) 2256.54 ± 20.29 (liver) 1554.63 ± 40.33 (kidney)	65.07 ± 2.57 (muscle) 59.05 ± 4.94 (liver) 164.79 ± 12.26 (kidney)	227.43 ± 4.64 (muscle) 207.59 ± 3.62 (liver) 164.30 ± 3.37 (kidney)
Tomović et al., 2017	635 ± 44 (liver) 1670 ± 90 (kidney) 725 ± 40 (heart)	2910 ± 170 (liver) 2350 ± 190 (kidney) 2770 ± 80 (heart)	142 ± 41 (liver) 166 ± 30 (kidney) 107 ± 19 (heart)	190 ± 10 (liver) 176 ± 11 (kidney) 201 ± 8 (heart)
Nieto et al., 2018	884 ± 204 (sausages) 1027±585 (bacon) 1255±738	–	–	–

Potassium values in fresh meat and organs ranged from 1500 to 3000 mg/kg (Nikolic et al., 2017; Tomović et al., 2011, 2017). The values of Ca and Mg for samples of fresh meat and organs ranged from 60 to 200 mg/kg and from 160 to 270 mg/kg, respectively, which are similar to the values obtained in our study. It can be concluded that fresh meat and organs have lower Na content than canned and processed meat and fishery products.

Macroelement content in raw materials, spices, and additives

The content of macroelements in raw materials, spices, and additives used to produce BG and MB samples and stored for 3 months and 1 month, respectively, was examined to roughly assess their contribution to the final concentration in the analyzed food. The results are presented in Table 3. Regarding the results related to BG, the highest sodium value was found in table salt (389000.0 mg/kg, but a high value was also found in the sample of dry onion –1068.5 mg/kg). High values of potassium were found in beef meat (4089.9 mg/kg) and very high in dry onion (12539.5 mg/kg) and ground red pepper (31774.4 mg/kg). Even though the portion of dry onion and red ground pepper in the BG sample is small, their contribution to the total potassium content in the final product is significant due to the high concentration of K in the mentioned additive and spice. The highest Ca and Mg contents were again found in dry onion and ground red pepper, which indicates that they are a significant source of minerals.

In the case of MB, macroelements were determined in starting raw materials (beef and pork meat and tomato sauce), dry onion, ground red pepper, flour, sugar, dish supplement, food additive, and kitchen salt. Except in kitchen salt, high sodium values were found in dried and minced onions (1155.0 and 1316.9 mg/kg) and tomato sauce (5150.8 mg/kg), while extremely high values were found in minced pepper (83831.8 mg/kg), dish supplement (284383.0 mg/kg) and food additive (363004.8 mg/kg). High potassium values were found in flour (1560.2 mg/kg), dish supplement (2214.5 mg/kg), beef and pork meat (3471.7 and 3477.6 mg/kg), and tomato sauce (4907.4 mg/kg) while extremely high K values (11182.7 and 28360.3 mg/kg) were recorded in dry onion and ground red pepper. Ground red pepper looks like a very desirable kind of spice for the dishes based on meat since it possesses very high K contents and low Na levels. The high Ca content was found in ground red pepper (2082.7 mg/kg), minced onion (2611.3 mg/kg), and dry onion (3221.3 mg/kg), while high Mg content was found in dry onion (995.9 mg/kg) and ground red pepper (1937.8 mg/kg). These results indicate ground red pepper again as a spice representing a significant source of minerals (Table 3). Based on the determined macroelement concentrations, it can be concluded that spices and additives, except for the raw materials, can affect the concentration of macroelements in the finished product. The quality and safety of the raw materials, spices, and additives in terms of the content of macroelements must be constantly monitored to prevent harmful effects on consumer health.

Table 3. Macroelements in raw materials, spices, and additives for the production of BG and MB, and the content of macroelements in BG and MB before and after the sterilization process.

Raw materials, spices and additives	Macroelements, mg/kg			
	Na	K	Ca	Mg
Beef goulash (BG)				
Beef meat	631.4	4089.9	58.3	252.9
Beef tallow	16.9	52.9	24.4	8.4
Dry onion	1068.5	12539.5	3669.0	1265.7
Ground red pepper	260.6	31774.4	2521.8	2224.5
Kitchen salt	389000.0	3.8	< 0.1	< 0.1
BG before sterilization	067.0	789.1	95.6	181.3
BG after sterilization	497.3	583.3	88.1	171.6
Meatballs in tomato sauce (MB)				
Beef meat	564.1	3471.7	59.6	248.7
Pork meat	479.1	3477.6	65.1	216.5
Tomato sauce	5150.8	4907.4	211.2	201.5
Dry onion	1155.0	11182.7	3221.3	995.9
Ground red pepper	218.7	28360.3	2082.7	1937.8
Minced onion	1316.9	28.8	2611.3	112.4
Minced pepper	83831.8	621.1	155.6	74.8
Dish supplement	284383.0	2214.5	539.7	184.8
Additive	363004.8	2.9	1.9	< 0.1
Flour	35.6	1560.2	235.0	312.7
Sugar	32.7	32.4	30.6	3.7
Kitchen salt	391341.8	3.2	< 0.1	< 0.1
MB before sterilization	864.6	755.7	92.8	171.0
MB after sterilization	710.9	632.4	93.7	163.4

The influence of the sterilization process on macroelement content

After testing the starting materials, spices and additives, the next step was to test the contents of GG and MB cans for the presence of macroelements immediately before and after the sterilization process. The values of macroelements in the samples of BG and MB are shown in Table 3. All macroelement concentrations were lower after sterilization (10 to 15%) in both types of canned meat products. This finding again points to the assumption of the deposition of macroelements in the form of insoluble compounds on the walls of the cans.

Dietary intake assessment

Among the dietary factors associated with the current high blood pressure epidemic, sodium, potassium, calcium, and magnesium are particularly interesting. These nutrients play an essential role in controlling blood pressure levels (Karppanen et al., 2005). On the other hand, the body uses an increased blood pressure as the most potent physiological mechanism to prevent Na accumulation when intake is high. Interestingly, increased sodium excretion significantly improves higher potassium, calcium, and magnesium intakes.

Table 4. The intake of macroelements calculated from the mean concentration data and combined with the dietary information of consumers.

Type of food	Intake of macroelements through canned meat products			
	EMI[a)] mg/month		EDI[b)] mg/day	
	Regular	Emergency	Regular	Emergency
		Na		
BG	495.4	990.8	16.5	33.0
PR	1299.5	2599.0	43.3	86.6
SP	2069.5	4139.0	69.0	138.0
LP	1029.2	2058.4	34.3	68.6
MB	2253.7	4507.4	75.1	150.2
Total	7147.3	14294.6	238.2	476.4
AI (mg)			2000.0	2000.0
% (AI)			11.9	23.8
		K		
BG	357.2	714.4	11.9	23.8
PR	840.5	1681.0	28.0	56.0
SP	706.5	1413.0	23.5	47.1
LP	283.5	567.0	9.5	18.9
MB	936.9	1873.8	31.2	62.5
Total	3124.6	6249.2	104.1	208.3
AI (mg)			3500.0	3500.0
% (AI)			3.0	6.0
		Ca		
BG	16.2	32.4	0.5	1.0
PR	40.8	81.6	1.3	2.6
SP	85.7	171.4	2.9	5.8
LP	53.0	106.0	1.8	3.6
MB	45.0	90.0	1.5	3.0
Total	240.7	481.4	8.0	16.0
AR (mg)			750.0	750.0
% (AR)			1.1	2.1
		Mg		
BG	28.8	57.6	1.0	2.0
PR	67.6	135.2	2.2	4.4
SP	61.3	122.6	2.0	4.0
LP	29.9	59.8	1.0	2.0
MB	67.5	135.0	2.3	4.6
Total	255.1	510.2	8.5	17.0
AI (mg)			350.0	350.0
% (AI)			2.4	4.9

[a)] EMI – estimated monthly intake; [b)] EDI – estimated daily intake.

In contrast, Na deficiency during deficient intake or loss due to gastrointestinal causes, sweating, or considerable blood loss can be effectively prevented by lowering blood pressure (Iwahori et al., 2017). Nutrition studies show that Na intake significantly exceeds 2000 mg, a sufficient daily intake that is unlikely to affect blood pressure adversely. In contrast, the current average intake of K, Ca, and Mg is significantly lower than recommended. For example, in the United States, the average intake of these mineral nutrients is only 35–50% of the recommended intake (Bates et al., 2020). Ideally, Na intake values should be less than those of K; however, this is not usually the case. Today, the Na/K ratio is commonly above 0.57, reflecting a much higher intake of sodium and a significantly lower potassium intake than the adequate ones recommended by EFSA (2000 mg for Na and 3500 mg for K). Also, the Ca/Mg ratio attracts great attention because its value above 2 is associated with an increased risk of metabolic, inflammatory, and cardiovascular disorders (Sukumar et al., 2019). The evidence suggests that high Na intake and low K, Ca, and Mg intakes lead to the occurrence and maintenance of high blood pressure and metabolic syndrome in a large portion of the population. This is a consequence of the typical Western diet, which favors calorie-dense foods, usually like canned food.

Mean macroelement concentrations within this study were combined with dietary data to assess soldiers' exposure to Na, K, Ca, and Mg through canned meat consumption. EDI values were used to calculate their contribution to the adequate intake (AI) for Na, K, and Mg and the average requirement (AR) for Ca (EFSA, 2017). According to the nutrition plan, soldiers consume 160 g BG, 400 g PR, 450 g SP, 300 g LP, and 400 g MB monthly in regular conditions. The results are shown in Table 4. The canned food contributes 11.9% to the adequate intake of Na, and only 3.0, 1.1, and 2.4% to the adequate intakes of K, Ca, and Mg. In emergencies, such as staying in the field, the contribution of canned food to the adequate intake of macroelements is twice as high. Thus, the low consumption of canned food contributes very little to the average daily intake of macroelements. Apart from its significant energy value, this food type does not positively contribute to K, Ca, and Mg intakes or negatively to excessive Na intake. However, if individual meals are observed, it can be noticed that the Na content is exceptionally high in SP and MB and exceeds the recommended daily level of 2000 g. Consumers get more Na in just one meal than is needed for normal daily functioning of the body, when SP and MB are on the menu. Further, when SP, PR, or MB are on the menu, K content in one serving satisfies about 20–30% of daily needs because one portion contains 700–1000 mg of potassium. It can be concluded that some products may be reformulated in the future, especially SP and MB, in terms of Na content. Part of the table salt (NaCl) could be replaced by potassium chloride (KCl), significantly affecting the decrease in Na and the increase in K. However, it should be also taken into account that these meals are prepared for soldiers, often exposed to heavier physical activities that cause increased sweating and more pronounced Na loss. The younger, physically active population will not be affected by the increased Na intake as much as the elderly or sick people. However, long-term exposure to high Na values can lead to physiological changes and diseases in healthy and young people.

Conclusion

The storage period affected reducing macroelement concentration in the canned meat products. The content of Na was the highest among measured macroelements in all types of meat products. The highest mean Na and K contents were found in MB (5634.2 ± 1068.8 mg/kg and 2342.3 ± 295.7 mg/kg, respectively). The mean K content in BG, PR, and MB samples was above 2000 mg/kg, making these products a rich K source. However, none of the analyzed products was found to have a Na/K ratio below 1, which is desirable for good health. In the BG, PR, and MB samples, the mean values of Ca were about 100 mg/kg, while Mg means ranged from about 170 to 180 mg/kg. In contrast, the mean Ca values in SP, and LP samples were higher (≈170–190 mg/kg) than the mean Mg values (≈100–140 mg/kg). Among analyzed spices and additives, ground red pepper represented a significant mineral source, with very high K (≅30000.0 mg/kg) and Mg (≅2000.0 mg/kg) contents. After sterilization, the concentration of all macroelements was lower by approximately 10 to 15%. The rare consumption of canned food, predicted by soldiers' diet, contributes 11.9% to the adequate intake of Na, and 3.0, 1.1, and 2.4% to the adequate intake of K, Ca, and Mg.

Acknowledgements

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (contract No: 451-03-68/2022-14/200116).

References

Ahuja, J.K., Li, Y., Haytowitz, D.B., Bahadur, R., Pehrsson, P.R., & Cogswell, M.E. (2019). Assessing Changes in Sodium Content of Selected Popular Commercially Processed and Restaurant Foods: Results from the USDA: CDC Sentinel Foods Surveillance Program. *Nutrients*, *11* (8), 1754.

Anishchenko, O.V., Sushchik, N.N., Makhutova, O.N., Kalachova, G.S., Gribovskaya, I.V., Morgun, V.N., & Gladyshev, M.I. (2017). Benefit-risk ratio of canned pacific saury (Cololabis saira) intake: Essential fatty acids vs. heavy metals. *Food and chemical toxicology*, *101*, 8-14.

Atanasoff, A., Nikolov, G., Staykov, Y., Zhelyazkov, G., & Sirakov, I. (2013). Proximate and mineral analysis of Atlantic salmon (Salmo Salar) cultivated in Bulgaria. *Biotechnology in Animal Husbandry*, *29* (3), 571-579.

Bates, M., Gunn, J.P., Gillespie, C., & Cogswell, M.E. (2020). The Macronutrient Content of Sodium-Modified Foods Is Unchanged Compared with Regular Counterparts: An Evaluation of Select Categories of Packaged Foods in the United States, 2018. *Journal of the Academy of Nutrition and Dietetics*, *120* (7), 1133-1141.

Bilandžić, N., Sedak, M., Čalopek, B., Đokić, M., Varenina, I., Kolanović, B.S., Božić Luburić, Đ., Varga, I., & Hruškar, M. (2021). Dietary exposure of the adult Croatian population to meat, liver and meat products from the Croatian market: Health risk assessment. *Journal of Food Composition and Analysis*, *95*, 103672.

Bogden, J.D., & Klevay, L.M. (Eds.). (2000). *Clinical nutrition of the essential trace elements and minerals: the guide for health professionals*. Springer Science & Business Media.

Boufleur, L.A., dos Santos, C.E.I., Debastiani, R., Yoneama, M.L., Amaral, L., & Dias, J.F. (2013). Elemental characterization of Brazilian canned tuna fish using particle induced X-ray emission (PIXE). *Journal of Food Composition and Analysis*, *30* (1), 19-25.

Carnauba, R., Baptistella, A., Paschoal, V., & Hübscher, G. (2017). Diet-Induced Low-Grade Metabolic Acidosis and Clinical Outcomes: A Review. *Nutrients, 9* (6), 538.

Djinovic-Stojanovic, J.M., Nikolic, D.M., Vranic, D.V., Babic, J.A., Milijasevic, M.P., Pezo, L.L., & Jankovic, S.D. (2017). Zinc and magnesium in different types of meat and meat products from the Serbian market. *Journal of Food Composition and Analysis*, *59*, 50-54.

EFSA Scientific Report (2011). Overview of the procedures currently used at EFSA for the assessment of dietary exposure to different chemical substances. *EFSA Journal*, *9* (12), 2490.

EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). (2015a). Scientific opinion on dietary reference values for calcium. *EFSA Journal*, *13* (5), 4101.

EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). (2015b). Scientific opinion on dietary reference values for magnesium. *EFSA Journal*, *13* (7), 4186.

EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA), Turck, D., Castenmiller, J., de Henauw, S., Hirsch-Ernst, K.I., Kearney, J., & Naska, A. (2019). Dietary reference values for sodium. *EFSA Journal*, *17* (9), e05778.

European Food Safety Authority (EFSA). (2017). *Dietary reference values for nutrients summary report* (Vol. 14, No. 12, p. e15121E). https://doi.org/10.2903/sp.efsa.2017.e15121

Gillespie, C., Maalouf, J., Yuan, K., Cogswell, M.E., Gunn, J.P., Levings, J., Moshfegh, A., Ahuja, J.C.K., & Merritt, R. (2015). Sodium content in major brands of US packaged foods, 2009. *The American journal of clinical nutrition*, *101* (2), 344-353.

Goff, J.P. (2018). Invited review: Mineral absorption mechanisms, mineral interactions that affect acid–base and antioxidant status, and diet considerations to improve mineral status. *Journal of Dairy Science, 101* (4), 2763-2813.

Iwahori, T., Miura, K., & Ueshima, H. (2017). Time to consider use of the sodium-to-potassium ratio for practical sodium reduction and potassium increase. *Nutrients*, *9* (7), 700. https://doi.org/10.3390/nu9070700

Karppanen, H., Karppanen, P., & Mervaala, E. (2005). Why and how to implement sodium, potassium, calcium, and magnesium changes in food items and diets? *Journal of human hypertension*, *19* (3), S10-S19.

Kogure, M., Nakaya, N., Hirata, T., Tsuchiya, N., Nakamura, T., Narita, A., & Hozawa, A. (2021). Sodium/potassium ratio change was associated with blood pressure change: possibility of population approach for sodium/potassium ratio reduction in health checkup. *Hypertension Research*, *44* (2), 225-231.

Morrissey, E., Giltinan, M., Kehoe, L., Nugent, A.P., McNulty, B.A., Flynn, A., & Walton, J. (2020). Sodium and Potassium Intakes and Their Ratio in Adults (18–90y): Findings from the Irish National Adult Nutrition Survey. *Nutrients*, *12* (4), 938. https://doi.org/10.3390/nu12040938

National Academies of Sciences, Engineering, and Medicine (2019). *Dietary Reference Intakes for sodium and potassium. Washington, DC:* The National Academies Press.

Nieto, C., Tolentino-Mayo, L., Medina, C., Monterrubio-Flores, E., Denova-Gutiérrez, E., & Barquera, S. (2018). Sodium Content of Processed Foods Available in the Mexican Market. *Nutrients*, *10* (12), 2008.

Nikolic, D., Djinovic-Stojanovic, J., Jankovic, S., Stanisic, N., Radovic, C., Pezo, L., & Lausevic, M. (2017). Mineral composition and toxic element levels of muscle, liver and kidney of intensive (Swedish Landrace) and extensive (Mangulica) pigs from Serbia. *Food Additives & Contaminants: Part A*, *34* (6), 962-971.

Park, Y.M., Choi, J.Y., Nho, E.Y., Lee, C.M., Hwang, I.M., Khan, N., & Kim, K.S. (2019). Determination of macro and trace elements in canned marine products by inductively coupled plasma—optical emission spectrometry (ICP-OES) and ICP—mass spectrometry (ICP-MS). *Analytical Letters*, *52* (6), 1018-1030.

Rubio, C., Napoleone, G., Luis-González, G., Gutiérrez, A.J., González-Weller, D., Hardisson, A., & Revert, C. (2017). Metals in edible seaweed. *Chemosphere*, *173*, 572-579.

Singh, M., & Chandorkar, S. (2018). Is sodium and potassium content of commonly consumed processed packaged foods a cause of concern? *Food chemistry*, *238*, 117-124.

Stojanović, B., Janković, S., Đorđević, V., Marjanović, S., Vasilev, D., Stojanović, Z., Balaban, M., & Antić, V. (2021). Determination of toxic elements in meat products from Serbia packaged in tinplate cans. *Environmental Science and Pollution Research, 28*, 48330-48342.

Sukumar, D., DeLuccia, R., Cheung, M., Ramadoss, R., Ng, T., & Lamoureux, A. (2019). Validation of a Newly Developed Food Frequency Questionnaire to Assess Dietary Intakes of Magnesium. *Nutrients*, *11* (11), 2789.

Tomović, V.M., Petrović, L.S., Tomović, M.S., Kevrešan, Ž.S., & Džinić, N.R. (2011). Determination of mineral contents of semimembranosus muscle and liver from pure and crossbred pigs in Vojvodina (northern Serbia). *Food Chemistry*, *124* (1), 342-348.

Tomović, V.M., Jokanović, M.R., Pihler, I.I., Švarc-Gajić, J.V., Vasiljević, I.M., Škaljac, S.B., & Tomašević, I.B. (2017). Ultimate pH, colour characteristics and proximate and mineral composition of edible organs, glands and kidney fat from Saanen goat male kids. *Journal of Applied Animal Research*, *45* (1), 430-436.

Vafaei, M., Naseri, M., & Imani, A. (2018). Long-term storage effect on some mineral elements of canned silver carp (*Hypophthalmichthys molitrix*) with reference to daily intake changes. *Journal of Food Composition and Analysis*, *66*, 116-120.

World Health Organization. (2012a). *Guideline: Potassium intake for adults and children*. https://www.who.int/publications/i/item/9789241504829

World Health Organization. (2012b). *Guideline: Sodium intake for adults and children*. https://www.who.int/publications/i/item/9789241504836

Received: February 26, 2022
Accepted: November 1, 2022

KONZERVISANI MESNI PROIZVODI ZA VOJSKU SRBIJE: SADRŽAJ Na, K, Ca, I Mg I ZDRAVSTVENI RIZICI/BENEFITI

Branislav Đ. Stojanović[1], Zdenka M. Stojanović[2], Sonja S. Marjanović[2], Saša D. Janković[3], Mališa P. Antić[4], Milica R. Balaban[5] i Vesna V. Antić[4*]

[1]Ministarstvo odbrane, Uprava za vojno zdravstvo,
Crnotravska 17, 11000 Beograd, Srbija
[2]Univerzitet odbrane, Vojnomedicinska akademija,
Crnotravska 17, 11000 Beograd, Srbija
[3]Institut za higijenu i tehnologiju mesa,
Kaćanskog 13, 11000 Beograd, Srbija
[4]Univerzitet u Beogradu-Poljoprivredni fakultet,
Nemanjina 6, 11080 Beograd-Zemun, Srbija
[5]Univerzitet u Banjoj Luci, Prirodno-matematički fakultet,
Mladena Stojanovića 2, 78000 Banja Luka, Bosna i Hercegovina

R e z i m e

Makroelementi kao što su Na, K, Ca i Mg igraju značajnu fiziološku ulogu, a njihov neadekvatan unos se dovodi u vezu sa teškim oboljenjima kao što je visok krvni pritisak. Podaci o proceni rizika po zdravlje ljudi u Srbiji, od unosa ovih makroelemenata preko konzumiranja konzervisane hrane, su minimalni. Zbog toga je ispitan sadržaj Na, K, Ca i Mg u pet vrsta mesnih konzervi koje pripadnici Vojske Srbije redovno koriste. Makroelementi su određeni metodom masene spektrometrije sa induktivno spregnutom plazmom, u konzervama goveđeg gulaša, svinjskog paprikaša, mesnog nareska, jetrene paštete i ćufti u paradajz sosu, koje su skladištene u periodu od mesec dana do šest godina. Sadržaj natrijuma je bio značajno veći od sadržaja kalijuma u svim vrstama hrane, tako da odnos Na/K ispod 1, poželjan za dobro zdravlje, nije pronađen ni u jednom analiziranom proizvodu. Takođe, značajan broj uzoraka je imao nepovoljan Ca/Mg odnos veći od 1. Međutim, zbog niske potrošnje konzervisane hrane od strane pripadnika Vojske Srbije, njen doprinos prosečnom dnevnom unosu makroelemenata je skoro zanemarljiv. Koncentracija makroelemenata opadala je sa rokom trajanja, dok je značajan izvor Ca i Mg, među analiziranim sastojcima, bila mlevena crvena paprika.

Ključne reči: makroelementi, konzervisani mesni proizvodi, skladištenje, dnevni unos, visok krvni pritisak, procena rizika.

Primljeno: 26. februara 2022.
Odobreno: 1. novembra 2022.

[*]Autor za kontakt: e-mail: vantic@agrif.bg.ac.rs