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QUALITY OF FOOD-GRADE SALT IN THE UKRAINIAN MARKET:ELEMENTAL COMPOSITION

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Abstract. The elemental composition of table salt around the world is of considerable interest. Following the full-scale invasion of 2022-2023, the quality of table salt in Ukraine in the period required additional research. Therefore, we analyzed 10 samples of table salt from Ukrainian retail chains by country of origin (Romania, Turkey, Greece, Poland, Italy, Israel, Ukraine) for the content of Fe, Zn, Co, Ba, Cr, Mn, Mo, Ni, Si, V, Cd, Cu, Pb, and Sr using inductively coupled plasma mass spectrometry (ICP-MS). The zinc (Zn) content in salt of Ukrainian origin that was re-exported from Azerbaijan was 0.054 ppm, while a sample from SE "Artyomsol" had a content of 0.1035 ppm. The barium (Ba) content in a mixed sample (SE "Artyomsol"-Romania-Turkey) was 1.1750 ppm, which is significantly higher than in all other salts, where the content ranged from 0.0036 to 0.33 ppm. The nickel (Ni) content in the re-exported salt from Azerbaijan was 0.0032 ppm, almost 2.3 times higher than in the SE "Artyomsol" sample. Compared to the same sample, the silicon content was 1.45 times higher, and the strontium content was 1.8 times higher. Contamination with sand, barium salts, and violations of storage conditions are possible reasons that affected the comparability of the above values. In all the salt samples, silicon, molybdenum, manganese, and iron were the quantitatively predominant elements, despite the different origins of the salts. The cobalt (Co) content in all studied salt samples was the most consistent, with an average of 0.00179 ppm. The analysis showed that salt from Romania contained the most zinc and cadmium, and salt from Italy contained the most lead and strontium. An incomparable excess of lead was recorded in the mixed sample. Salt of Ukrainian origin is among the top five in terms of manganese, zinc, cobalt, chromium, molybdenum, vanadium, and iron content. The sample of salt from Drohobych saltworkscontained the lowest amount of toxic elements, and no strontium was detected at all, which makes it a leader in quality.

Keywords: sodium chloride, table salt, toxic element, inductively coupled plasma mass-spectrometry, Drohobych saltworks, chemical analysis.

Introduction. Formulation of the problem

Sodium chloride, found as the natural mineral halite, plays an key role in the global circulation of essential irreplaceable chemical substances. The world's geological reserves of sodium chloride are inexhaustible [1].

In everyday life, everyone comes into contact with sodium chloride, also known as food, table, or cooking salt, several times a day. Natural and artificial brines or seawater can also be used as raw materials for producing table salt. Depending on the method of salt production, its mineral composition will differ, and accordingly, its effect on health can be both beneficial and harmful. The regulated indicators for toxic elements are defined by DSTU 3583:2015 Table salt.

The World Health Organization (WHO) recommends reducing salt intake to 5 g of NaCl (or 2 g of Na+) per day [2]. Of course, salt is not the main source of elements in the human body, but it is a regular one, and there is much to say about their indispensability. Accordingly, with a decrease in daily requirements, the amount of elements entering the body with salt will be reduced. Summarizing their role, it is worth noting that iron ensures the even distribution of oxygen throughout the body. Cobalt promotes iron absorption and participates in enzymatic processes. Zinc supports immunity and keeps the skin in good condition.

Barium affects smooth muscles. Chromium affects blood glucose regulation. Manganese is a component of many enzymes and participates in the metabolism of thyroid hormones and neurotransmitters in the nervous system. Molybdenum is also a component of a number of enzymes and participates in the regulation of uric acid metabolism. Nickel affects enzymatic processes, can inhibit the action of adrenaline and lower blood pressure. Silicon affects lipid metabolism, collagen and bone tissue formation, and with age, it is important to consume additional silicon to prevent atherosclerosis, as its amount in the body decreases. Vanadium is a generally understudied element, but it is believed to regulate carbohydrate metabolism and cardiovascular activity, as well as bone and tooth tissue metabolism [3].

Analysis of recent research and publications

There is considerable interest in the elemental composition of table salt around the world. Between 2005 and 2022, numerous studies were conducted on the elemental composition, mainly focusing on the content of toxic elements in various types of table salt in Australia, Ghana, Turkey, Egypt, Greece, and Iran [4,5,6,7,8,9,10,11,12].

According to the Codex Alimentarius Commission, flame atomic absorption spectrophotometry (FAAS), inductively coupled plasma optical emission spectroscopy (ICP-OES), and inductively coupled plasma mass spectrometry (ICP-MS) are the most commonly used methods for determining chemical elements [3,13].

A 2017 study of food salts from deposits in Pakistan for heavy metal content (Cd, Fe, Cu, Mn, Cr) showed that the content of toxic elements was within acceptable limits, with no violations regarding lead content. All 12 samples of salt from different parts of Pakistan were obtained from local residents. The study was conducted using an atomic absorption spectrophotometer [14].

In 2023, scientists from Italy, the most gastronomic country in Europe, studied the dependence of the mineral content of different salts on their type and geographical origin. Ten samples of salt commercially available in southern Italy were tested for the content of 12 elements: Al, Ca, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, and Zn. The content of Co, Cr, Cu, Hg, Pb, and Se was acceptable, while the content of Al, Ca, Fe, Mn, Ni, and Zn varied significantly between samples. It should be noted that the Pb content exceeded the maximum level in all samples. The composition was analyzed using inductively coupled plasma mass spectrometry (ICP-MS) and thermal decomposition atomic absorption spectrophotometry (TDA-AAS) [15]. The excess lead in the Italian studies is mainly attributed to anthropogenic pollution. Scientists note that in order to control human safety and health, it is necessary to study all salt samples in the world [15].

Background of the study

Ukraine has reserves of all types of salt. The geography of distribution and possible extraction of edible salt is found in all regions of Ukraine particularly in Donbas, in the Dnipro-Donets Basin, in the Carpathian Foothills, Transcarpathia, the Western Black Sea Region, namely the Preddobrudzhinsky Progyn and in the lakes and estuaries of the Black and Azov Seas [1].

However, due to the full-scale invasion by the Russian Federation since 2022, the Drohobych Saltworks is the only operating and historically significant facility for producing evaporated salt in Ukraine [16]. The permissible mass fraction of potassium according to DSTU 3583:2015 Table salt for salt from the Drohobych saltworks, as an element essential for human life, is no more than 0.42% in dry matter, or 21 mg / 5 g NaCl. The daily requirement of potassium ions for the human body is 2000-2500 mg [3].

It was the regularity of salt consumption that became the impetus for iodizing salt in the fight against iodine deficiency. According to DSTU 3583:2015, the mass fraction of iodine in iodized salt should be $(40 \pm 15) \cdot 10^{-4}$ %. Most of the iodine is stored in the thyroid gland. In fact, iodine is key in the production of thyroid hormones, which affect overall metabolism. Therefore, the biochemical role of iodine in the human body is extremely important [17]. There is a global program for iodizing salt, but iodine deficiency remains a global problem despite improvements in the iodine status of the population in some regions,[18]. Most Ukrainians consume little iodine; statistical studies in 2021 recorded 90 μg in women [19]. Achieving an optimal iodine intake from iodized salt (in the range of 150-250 μg /day for adults) can minimize thyroid dysfunction in the population) [20].

A 2019 qualitative analysis of iodized salt from three brands conducted in Ukraine to determine the presence or absence of heavy metal salts found that all samples contained heavy metals, but the salt produced by Kozachenka was less contaminated with impurities than the salt produced by SE "Artyomsol" and Salute di Mare [21].

Today, even with increased capacity, the only salt factory in Ukraine, located in Dorogobych, is unfortunately unable to fully meet the needs of Ukrainian consumers for table salt, so salt has been imported into Ukraine since 2022. Due to the shortage of products on the market, many different suppliers have appeared and problems with quality control have arisen, especially during transportation, storage, and packaging. During transportation and storage, rock salt and evaporated salt can become contaminated with microflora that was not present at the time of extraction. It has been established that rock salt is more contaminated with microbes than evaporated salt, and salt iodization helps reduce the content of microorganisms [22].

It should be noted that among the variety of imported goods in 2023, the shelves of Ukrainian retail outlets also featured re-exports SE "Artyomsol" salt from Azerbaijan and packages of mixed salt samples from SE "Artyomsol", Romania, and Turkey.

Aim and objectives of the study

The aim of the research was to investigate the quality of salt available in retail chains in the period following the full-scale invasion and immediately after the crisis caused by the lack of salt on store shelves, i.e., in 2022-2023.

The objectives were:

1) to investigate the elemental composition of available food salts according to their countries of origin;

2) to conduct a comparative analysis of foreign and Ukrainian salt;

3) to investigate salt for possible contamination with heavy (toxic) elements.

Research materials and methods

In August 2023, 18 samples of table salt from seven countries of origin were purchased from various retail chains in the western region of Ukraine with a packaging date of 2022-2023, when store shelves were once again filled with salt packages. Salt packaged or manufactured by different suppliers was purchased. The purchase was not based on salt brands or specific trademarks; the only interest was in the country of origin of the salt. The study was conducted to determine the content of mineral elements (Fe, Zn, Co, Ba, Cr, Mn, Mo, Ni, Si, V), including heavy metals (Cd, Cu, Pb, Hg) and radionuclides (Sr) using an ICP-MS device, Thermo Scientific, USA (the methodology was set and the parameters were established by the equipment manufacturer).

In particular, analysis was carried out on salts from Romania, Turkey, Greece, Poland, Italy, Israel, and Ukraine. Microelement analysis was carried out on three salt samples from Romania, six salt samples from Turkey, one sample each from Poland, Greece, Israel, and Italy, as well as two samples from Ukraine, one sample of Drohobych salt, one sample of re-exported SE "Artyomsol" salt from Azerbaijan, and one mixed salt sample: SE "Artyomsol"-Romania-Turkey. The total summary of indicators during the mathematical averaging of the analyzed salt samples consisted of 10 items: 6 from abroad and 4 samples of Ukrainian origin (see Table 1 and Table 2).

Results of the research and their discussion

Mineral elements

The average values of mineral elements in ppm (mg/kg) are presented in Table 1.

The iron content in Ukrainian-produced salt and re-exported salt from Azerbaijan is comparable and was within the acceptable measurement error. The mixed sample cannot be compared with the iron content in individual salts from Romania, Turkey, and Ukraine. The discrepancy in measurement is >2.14 times. The regulated iron content in terms of Fe_2O_3 is 0.005-0.04% according to DSTU 3583:2015 Table salt. In all samples studied, the Fe_2O_3 content did not exceed $6 \cdot 10^{-5}$%. In a state of physiological equilibrium, the daily requirement of Fe for an adult is 1.0-1.5 mg [23]. The highest amount of iron can enter the human body when consuming salt from Greece and Israel (0.019 mg), and the lowest amount is 0.23 μg when consuming salt from Drohobych.

In terms of its participation in metabolic processes, zinc ranks second after iron in terms of its prevalence in the human body and is one of the essential trace elements [24]. In terms of Zn content, the mixed salt sample corresponds to the studied samples of salts from Romania and Turkey. The lower zinc content in the re-exported SE "Artyomsol" salt can be explained by the higher moisture content in this salt. The zinc content in evaporated Drohobych salt was 10 times lower than in samples of rock salt of Ukrainian origin and salt from Romania. The zinc content in all salt samples varies significantly.

Cobalt increases iron absorption and hemoglobin synthesis and enters the body with food [3]. In salt samples from different countries, its content is relatively insignificant and evenly distributed with an acceptable measurement error, ranging from 0.011 to 0.0032 ppm.

Since barium is absorbed 4-6 times faster in the respiratory tract than through the gastrointestinal tract, salt is not a source of barium intake in the human body. The daily requirement is 0.3-1 mg. [3] An actual excess is observed only for mixed salt sample, but this does not exceed the toxic dose of 200 mg. The cause of contamination may be improper conditions for obtaining table salt. 5.889 μg of barium from mixed salt sample can enter the body per day, which is significantly below permissible limits.

The highest chromium content was found in table salt from Israel. It's intake into the body will be 0.69 mg, which is 72 times less than the minimum daily requirement [3]. For salts from other countries, the levels are even lower, with the average daily requirement being $1 \cdot 10^5$ times lower for re-exported salt from Azerbaijan and 227 times lower for salt from Greece. The underestimated figures for re-exported salt from Azerbaijan are almost 20 times lower than the data for SE "Artyomsol" salt, but this can be explained by the high moisture content in the sample. Table salt is not the main source of chromium in the body, but in cases of chromium poisoning, it is recommended to reduce salt intake [25].

Table 1 – Average mineral content in the salt samples studied, ppm

No	Country	Element				
		Fe	Zn	Co	Ba	Cr
1.	Romania	0,293	0,1387	0,0027	0,3300	0,0023
2.	Turkey	0,097	0,0989	0,0013	0,0350	0,0012
3.	Poland	0,121	0,0910	0,0011	0,0270	0,00065
4.	Greece	0,383	0,1320	0,0015	0,0110	0,0440
5.	Israel	0,362	0,0545	0,0032	0,0380	0,1380
6.	Italy	0,134	0,0914	0,0002	0,0036	0,0006
7.	Ukraine	0,132	0,1035	0,0017	0,0300	0,0019
8.	Drohobych	0,046	0,0112	0,0021	0,0190	0,0018
9.	Re-exported salt from Azerbaijan	0,118	0,0540	0,0025	0,0310	0,0001
10	Mixed salt sample: SE "Artyomsol"-Romania-Turkey	0,0435	0,1130	0,0017	1,1750	0,0015
No	Country	Element				
		Mn	Mo	Ni	Si	V
1.	Romania	0,079	0,016	0,0050	0,483	0,0036
2.	Turkey	0,150	0,103	0,0040	0,262	0,0018
3.	Poland	0,130	0,023	0,0028	0,470	0,0012
4.	Greece	0,167	0,204	0,0480	0,340	0,0037
5.	Israel	0,365	0,207	0,1160	1,500	0,0048
6.	Italy	0,572	0,421	0,0005	0,500	0,0002
7.	Ukraine	0,168	0,055	0,0014	0,454	0,0018
8.	Drohobych	0,039	0,122	0,0029	0,421	0,0024
9.	Re-exported salt from Azerbaijan	0,074	0,102	0,0032	0,660	0,0017
10	Mixed salt sample: SE "Artyomsol"-Romania-Turkey	0,062	0,0039	0,0019	0,38	0,0017

The lowest amount of manganese is observed in Drohobych salt, and the highest amount in Italian salt. In salts from Turkey, Poland, Greece, and Ukraine, the amount of manganese was within the margin of error and amounted to only 0.02% of the daily requirement [3]. Re-exported salt from Azerbaijan contains 94 μg less manganese than salt from SE "Artyomsol". Within the margin of error, the composition of the mixed sample coincides with the manganese content in salt from Romania.

There was 47.5 μg more molybdenum in salt re-exported from Azerbaijan than in salt from Ukraine, and the amount of molybdenum in the mixed sample was likely influenced by the higher mass fraction of moisture in the sample. The highest amount of molybdenum was found in Italian salt – $2\cdot10^{-6}$ μg for 5 g of salt, which is $2.81\cdot10^{-6}$ times less than the daily requirement.

Only 0.58% of the minimum daily requirement for nickel will come from salt from Israel, where the nickel content is the highest. And as stated in [3], only 1-10% of it is absorbed by the body, so the intake of nickel with salt can actually be negated. It is likely that foreign contaminants during repackaging contributed to an increase in the amount of nickel in salt from Azerbaijan.

In terms of indicators, silicon is second only to strontium in salt, but its maximum value is only 15.0% of the minimum daily requirement for humans, and this is recorded in salt from Israel. The excess in re-exported salt compared to SE "Artyomsol" salt is explained only by contamination with sand during the repackaging of salt.

The toxic dose of vanadium for humans is 0.25 mg [3]. The maximum value of vanadium in salt from Romania is 0.007% less than the toxic dose. The minimum amount was found in salt from Italy. In salts from Romania, Greece, and Israel, the amount of vanadium is actually twice as high as in other salts. The data for re-exported salt from Azerbaijan and salt from SE "Artyomsol" are comparable.

Heavy mineral elements

The average values of heavy (toxic) mineral elements in ppm are presented in Table 2.

Salt safety indicators in Ukraine are regulated by the normative documentation. In Ukraine it is DSTU 3583:2015, in worldwide it is COMMISSION REGULATION (EU) 2023/915. The content in ppm of toxic elements: mercury, arsenic, copper, lead, cadmium, and zinc should be respectively≥: 0.01; 1.00; 3.00; 2.00; 0.1; 10.00, according to DSTU 3583:2015. According to COMMISSION REGULATION (EU) 2023/915, their content should be for mercury ≥0.1 ppb (μg/kg); arsenic ≥0.5 ppb; lead ≥1(2) ppb; cadmium ≥0.5 ppb.

No exceedances of regulatory values for lead were observed in the salt samples studied. The daily lead requirement is 10-20 μg. Lead mainly enters the human body through the gastrointestinal tract [3].

Table 2 - Average heavy element content in the salt samples studied, ppm

No	Country	Element			
		Cu	Pb	Cd	Sr
1.	Romania	0,0073	0,028	0,0032	1,425
2.	Turkey	0,0010	0,0080	0,0009	2,895
3.	Poland	0,0025	0,0151	0,0003	1,880
4.	Greece	0,0022	0,0003	0,0006	3,239
5.	Israel	0,0033	0,0250	0,0011	4,244
6.	Italy	0,0024	0,0390	0,0012	5,170
7.	Ukraine	0,0025	0,0120	0,0009	2,342
8.	Drohobych	0,0001	0,0030	0,0004	-
9.	Re-exported salt from Azerbaijan	0,0029	0,0160	0,0016	4,220
10.	Mixed salt sample: SE "Artyomsol"-Romania-Turkey	0,0097	0,0343	0,0007	1,580

The highest lead content was observed in the mixed salt sample; it did not correspond to the values of individual analyses but was within the possible measurement error. Therefore, consumption of such salt will contribute to the intake of the highest amount of lead – 0.14 µg per day – into the human body.

The daily requirement for cadmium is 1-5 µg. The presence of other bioelements, particularly Ca, Zn, and Cu, significantly affects the absorption of cadmium [3]. The quantitative content of cadmium is relatively uniform across all countries of origin and ranges from 0.0003 to 0.0032 ppm, and the daily intake into the human body will be 0.0015-0.016 ppb, respectively.

The daily requirement for strontium is 0.8-3.0 mg. It should be noted that data on its toxicity to humans has not been determined [3]. Strontium was not detected only in the salt sample from Drohobych. More than half of the permissible strontium content is found in Italian salt (5.17 ppm). In re-exported salt from Azerbaijan, the strontium content was actually twice as high as that of SE "Artyomsol" salt.

Summary of data by country of origin.

Mineral elements

According to Table 1, silicon is quantitatively predominant in the samples of salts from Romania, Turkey, and Poland. A relatively significant silicon content is also observed in samples of Ukrainian salt from Drohobych, from SE "Artyomsol", and in re-exported salt from Azerbaijan. Among the elements in the salt samples studied, iron has the highest content, while manganese has the highest content in samples of salt from Israel and Italy.

It should be noted that for all samples studied, the elemental composition is within the norms and acceptable measurement errors. Only iodized table salt is a source of regulated iodine intake in the human body. For the purpose of comparison and determination of the quantitative element composition of salt samples purchased from various retail chains, diagrams (Fig. 1) and the portion ratio of the salt sample most rich in mineral elements are provided. To do this, we determined which element is most abundant in each country.

Below are represented the range of the top five countries of origin of salt in order from highest to lowest mineral content:

1) Iron: Greece – Israel – Romania – Italy – Ukraine;
2) Zinc: Romania – Greece – Mixed sample – Ukraine – Turkey;
3) Cobalt: Israel – Romania – Azerbaijan – Ukraine – Mixed sample;
4) Barium: Mixed sample – Romania – Israel – Turkey – Azerbaijan;
5) Chromium: Israel – Greece – Romania – Ukraine – Drohobych;
6) Manganese: Italy – Israel – Ukraine – Greece – Turkey;
7) Molybdenum: Italy – Israel – Greece – Drohobych – Turkey;
8) Nickel: Israel – Greece – Romania – Turkey – Poland;
9) Silicon: Israel – Azerbaijan – Italy – Romania – Poland;
10) Vanadium: Israel – Greece – Romania – Drohobych – Ukraine

The theoretical portion ratio of the best mineral composition salt for the human body within the daily requirement (5 g) as a mixture of the samples studied will be: 1.5 g of salt from Israel, 1.3 g of salt from Italy, 0.7 g of salt from Greece, 1.4 g of salt from Romania, and 0.1 g of the mixed salt sample SE "Artyomsol"-Romania-Turkey. The amount of elements that will enter the human body per day will be: 0.0268 µg Fe, 0.01946 µg Zn, 0.00048 µg Co, 0.1175 µg Ba, 0.0207 µg Cr, 0.0744 µg Mn, 0.05473 µg Mo, 0.0174 µg Ni, 0.2250 µg Si, 0.00072 µg V.

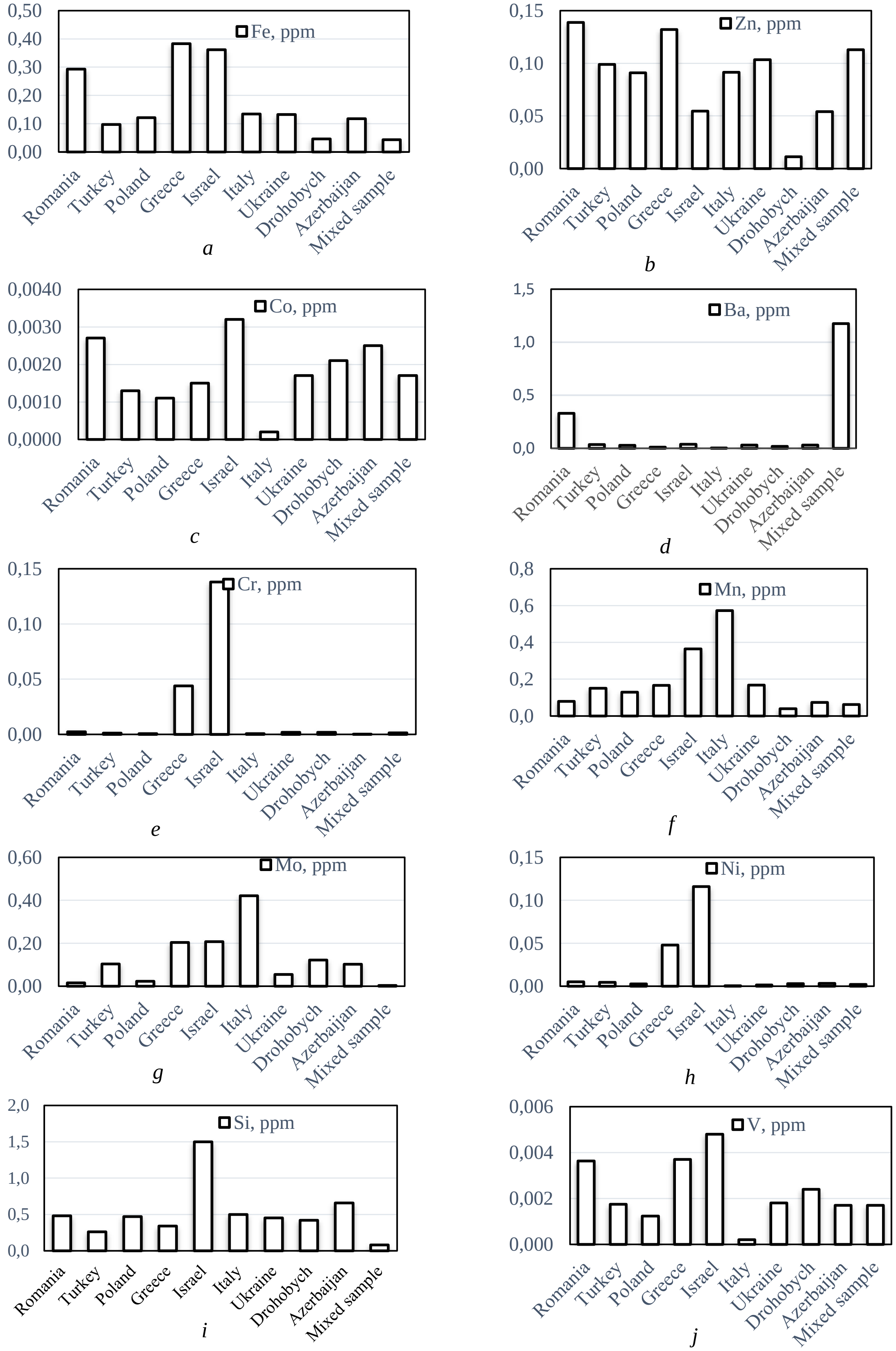


Fig. 1. Element content in ppm: a) iron; b) zinc; c) cobalt; d) barium; e) chromium; f) manganese; g) molybdenum; h) nickel; i) silicon; j) vanadium in the studied samples of salts from different countries of origin

Heavy mineral elements

According to Table 2, the amount of strontium in the samples studied was the highest compared to other elements. The lowest amount of heavy elements was found in the salt sample from Drohobych, where no strontium was detected at all. The highest amounts of strontium and lead were found in salt sample from Italy, while the mixed sample contained higher levels of copper and lead. A significant amount of lead was found in salt sample from Italy, which is comparable to the studies of Italian scientists, where the values were in the range of 5.6-7.2 ppm, which is 2.8-3.6 times higher than the established norms in Ukraine [4]. The highest amount of cadmium was found in salt sample from Romania.

Below are represented the range of the top five countries of origin of salt samples in descending order of heavy element content:

1) Copper: Mixed sample – Romania – Israel – Azerbaijan – Poland;

2) Lead: Italy – Mixed sample – Romania – Israel – Azerbaijan;

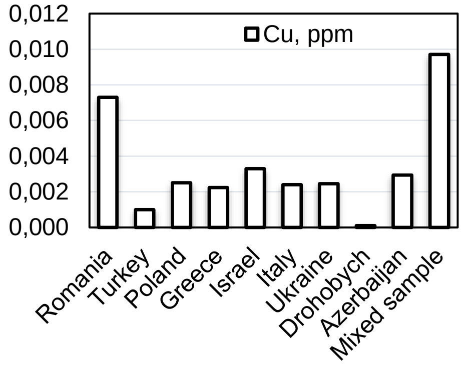
3) Cadmium: Romania – Azerbaijan – Italy – Israel – Ukraine/Turkey;

4) Strontium: Italy – Israel – Azerbaijan – Greece – Turkey.

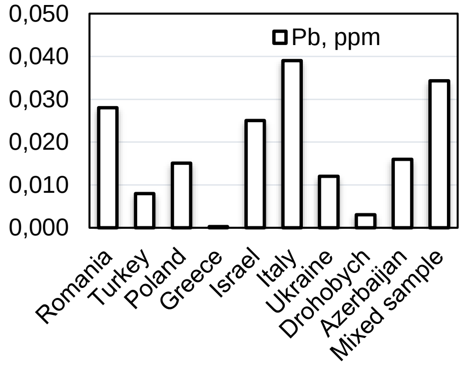
Therefore, the amount of heavy (toxic) elements that will enter the human body per day according to the theoretical the best mineral composition salt given above will be 0.0208 µg of copper; 0.131 µg of lead; 0.008 µg of cadmium; 17.39 µg of strontium.

Conclusion

There is interest in researching the elemental composition of table salt both globally and in Ukraine. Such research is necessary to monitor the safety of salt consumption. Some discrepancies were found between the elemental composition of Ukrainian-origin salt re-exported from Azerbaijan and mixed sample in 2022-2023 and sample from SE "Artyomsol" in terms of zinc, barium, nickel, and silicon content. The zinc content in salt of Ukrainian origin re-exported from Azerbaijan was half that of the SE "Artyomsol" sample. The barium content in the mixed sample: SE "Artyomsol"-Romania-Turkey exceeded the content of all other salts by an average of 20 times. The nickel content in salt re-exported from Azerbaijan was 0.0032 ppm, which is almost 2.3 times higher than in the SE "Artyomsol" sample. Compared to the same sample, the silicon content was 1.45 times higher, and the strontium content was 1.8 times higher. The sample of salt from Drohobych contained the lowest amount of toxic elements, and no strontium was detected at all.



a



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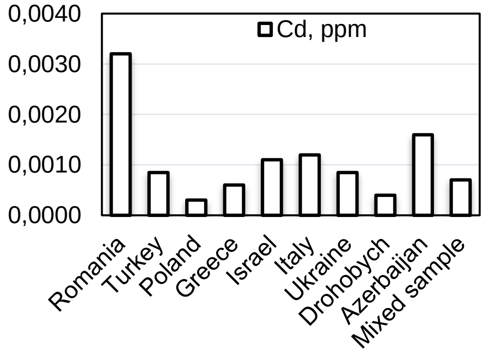

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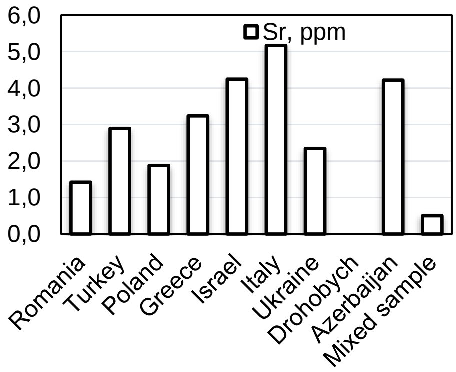

d

Fig. 2. Content of heavy mineral elements in ppm: a) copper; b) lead; c) cadmium; d) strontium in the studied samples of salts from different countries of origin.

Salt of Ukrainian origin is among the leaders (Romania, Turkey, Greece, Poland, Italy, and Israel) in terms of manganese, zinc, cobalt, chromium, molybdenum, and vanadium content. Salt of Ukrainian origin also contains a significant amount of iron. It was found that the cobalt content in the studied salt samples from different countries of origin was the most uniform and averaged 0.00179 ppm. It should be noted that although the origin of the salts was different, silicon, molybdenum, manganese, and iron predominated in all samples in terms of composition. Studies have shown a certain pattern between the elemental composition of salts of Ukrainian origin, possible causes (contamination with sand and barium salts), and conditions (humidity) of deviation values.

Thus, the quality of salt available on the shelves of retail chains in the western region of Ukraine with a packaging date of 2022-2023 was quite heterogeneous in terms of elemental composition, and the minimum content of toxic elements in Drohobych salt puts it in the leading position in terms of quality.

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ЯКІСТЬ ХАРЧОВОЇ СОЛІ НА РИНКУ УКРАЇНИ: ЕЛЕМЕНТНИЙ СКЛАД

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Анотація. Елементний склад харчової солі у світі складає значний інтерес. Якість харчової солі України у період після повномасштабного вторгнення 2022-2023 років потребувала додаткових досліджень. Тому, приведено дані 10 зразків харчової солі з торгівельних мереж України за країнами походження (Румунія, Туреччина, Греція, Польща, Італія, Ізраїль, Україна) на вміст: Fe, Zn, Co, Ba, Cr, Mn, Mo, Ni, Si, V, Cd, Cu, Pb, Sr досліджені методом мас-спектрометрії з індуктивно-зв’язаною плазмою (ICP-MS). Вміст Zn у солі українського походження реекспорту з Азербайджану склав 0,054 мг/кг, тоді як і у зразку ДП «Артемсіль» він становив 0,1035 мг/кг. Вміст барію у змішаному зразку: ДП «Артемсіль»-Румунія-Туреччина складав 1,1750 мг/кг, що значно вище, ніж у всіх інших солях, де вміст коливався в межах 0,33-0,0036 мг/кг. Вміст Ni у солі реекспорту з Азербайджану склав 0,0032 мг/кг, що практично у 2,3 рази більше, ніж у зразку ДП «Артемсіль». Порівнюючи з тим же зразком перевищення зафіксовано також за вмістом кремнію в 1,45 рази, за вмістом стронцію в 1,8 рази. Забруднення піском, солями барію, а також порушення умов зберігання – можливі причини, що вплинули на співставність вище наведених значень. У всіх зразків солі по складу кількісно переважали кремній, молібден, манган і залізо, незважаючи на різне походження солей. Вміст кобальту у всіх досліджуваних зразках солей був найбільш рівномірним і в середньому складав 0,00179 мг/кг. Показано, що у солі з Греції найбільше заліза, у солі з Ізраїлю – кобальту, хрому, нікелю, кремнію, ванадію, у солях з Румунії найбільше цинку і кадмію, а у солях з Італії найбільше плюмбуму і стронцію. По свинцю у змішаному зразку було зафіксовано неспівставне перевищення. Сіль українського походження серед п’ятірки лідерів за вмістом мангану, цинку, кобальту, хрому, молібдену, ванадію, заліза. У зразку солі з Дрогобича виявлено найменшу кількість токсичних елементів, а стронцій взагалі не виявлено, що ставить її на позицію лідера за якістю.

Ключові слова: натрій хлорид, харчова сіль, токсичний елемент, мас-спектрометрія з індуктивно зв'язаною плазмою, Дрогобицька солеварня, хімічний аналіз.