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DETERMINATION OF THE CONTENT OF CHEMICAL ELEMENTS IN THE "ASFAM" FOOD ADDITIVE

"ASFAM" OZIQ-OVQAT QO'SHILMASI TARKIBIDAGI KIMYOVIY ELEMENTLAR MIQDORINI ANIQLASH

ОПРЕДЕЛЕНИЕ СОДЕРЖАНИЯ ХИМИЧЕСКИХ ЭЛЕМЕНТОВ В ПИЩЕВОЙ ДОБАВКЕ «АСФАМ»

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Abstract

In experiments conducted using the ICP-OES method, the analysis of the food additive "Asfam," which is composed of mandarin and kiwi fruit peels, enabled the accurate quantification of 39 out of 69 chemical elements. The results showed that this food additive is rich in essential macroelements such as K, Ca, Mg, P, and Na, as well as biogenic microelements including Sn, Fe, Al, Sr, Si, Mn, Ba, Zn, B, Cr, Cu, Ni, Li, and Mo. It was proven that the levels of heavy metals and the toxic element arsenic in the "Asfam" food additive are significantly lower than the permissible limits.

Annotatsiya

Mandarin va kivi meva po`stloqlari kompozitsiyasi bo`lgan "Asfam" oziq-ovqat qoshilmasi tarkibidagi 69 ta kimyoviy elementni IBP OES usulida anliz qilish tajribalarida 39 ta elementning miqdorini yuqori aniqlikda topish imkonini bergan. Bu oziq-ovqat qo`shilmasi hayotiy zarur K , Ca, Mg, P, Na kabi makroelementlarga va Sn, Fe, Al, Sr, Si, Mn, Ba, Zn, B, Cr, Cu, Ni, Li, Mo kabi biogen mikroelementlarga boy ekanligini ko`rsatilgan. Og`ir metallar va zaharli mishyak elementining "Asfam" oziq-ovqat qo`shilmasidagi miqdoriy ko`rsatkichlari amalda ruxsat etilgan me'yorga nisbatan kam ekanligi isbotlangan.

Аннотация

В результате экспериментов по анализу пищевой добавки «Асфам», состоящей из кожуры мандарина и киви, методом ИСП-ОЭС удалось с высокой точностью определить количество 39 из 69 химических элементов. Установлено, что данная пищевая добавка богата жизненно важными макроэлементами, такими как K, Ca, Mg, P, Na, а также биогенными микроэлементами, включая Sn, Fe, Al, Sr, Si, Mn, Ba, Zn, B, Cr, Cu, Ni, Li и Mo. Доказано, что содержание тяжёлых металлов и токсичного элемента мышьяка в пищевой добавке «Асфам» значительно ниже допустимых пределов.

Key words: *"Asfam" food additive, kiwi peel, mandarin peel, macroelements, microelements, biogenic elements, ICP-OES method.*

Kalit so'zlar: *"Asfam" oziq-ovqat qo'shimchasi, kivi po'stlog'i, mandarin po'stlog'i, makroelementlar, mikroelementlar, biogen elementlar, IBP-OES metodi.*

Ключевые слова: *пищевая добавка «Асфам», кожура киви, кожура мандарина, макроэлементы, микроэлементы, биогенные элементы, метод ИСП-ОЭС.*

INTRODUCTION

A healthy lifestyle and proper nutrition are important factors for the normal functioning and development of the human body. Biologically active substances and minerals in food products support various physiological processes in the body. Citrus fruits, specifically the peels of mandarin, lemon, lime, and kiwi fruits, have long been used as healing agents in the food industry and traditional medicine.

For the healthy functioning, development, and proper progression of various physiological processes in the human body, a variety of nutrients are essential. Among these necessary substances, along with organic compounds (proteins, fats, carbohydrates, and vitamins), inorganic compounds (minerals) also play a vital role. Minerals are compounds required for the functioning of the nervous, circulatory, muscular, hormonal, and immune systems in the body [1]. Although they do not serve as an energy source in the human body, they act as key cofactors or structural components in maintaining normal metabolic processes and cellular functions [2]. The human body primarily obtains these substances from the external environment through nutrition [3, 4].

Mineral substances are classified into macroelements and microelements based on their quantity in the body. Macroelements are those required by the human body in relatively large amounts, specifically more than 100 mg per day. They are an integral part of the body's structure, being components of bones, muscles, blood, and cellular fluids, and they perform various physiological functions [2, 5, 6].

The "Asfam" food additive, developed by us based on the peels of kiwi and mandarin fruits and standardized for biologically active substances [7], can be used as a promising agent in modern medicine and traditional healing. This article presents the results and analysis of research conducted to determine the elemental chemical composition of this food additive using the inductively coupled plasma optical emission spectrometry (ICP-OES) method.

PREPARATION OF THE SAMPLE WORKING SOLUTION

The ash of 1.000 g of naturally dried and ground sample was obtained by heating in a porcelain crucible in a "Nabertherm" (Germany) muffle furnace up to 550 °C. The heating was performed in stages: first at 95 °C for 30 minutes, then at 120 °C for 60 minutes, followed by 300 °C for 120 minutes, and finally at 550 °C for 60 minutes, maintaining the temperature at 550 °C for 5 hours. To the resulting ash, 6 ml of 70% HNO_3 (Sigma Aldrich, USA) of ICP-MS grade and 2 ml of 60% H_2O_2 were added, then heated on an electric hot plate in a fume hood until the white fumes ceased. After cooling, the solution was transferred to a 100 ml polypropylene volumetric flask, and the volume was brought up to 100 ml with ultra-pure water. The prepared working solution was filtered using a syringe filter (0.45 µm) and used for analysis.

ANALYSIS PROCEDURE

The analysis was performed using the iCAP PRO X Duo ICP-OES inductively coupled plasma optical emission spectrometer manufactured by Thermo Fisher Scientific (USA). Method development and data analysis were carried out using the Thermo Scientific QTegra ISDS software platform. The analysis parameters are presented in Table 1.

Table 1.

Analysis Method Parameters.

Parameter	Settings	
Pump Tubing	Tygon® ellow/white for sample	Tygon® white/white for drain
Pump Speed	45 rpm	
Spray Chamber	Glass cyclonic	
Nebulizer	Glass concentric	
Nebulizer Gas Flow	0.6 $L \cdot min^{-1}$	
Cooling Gas Flow	12.5 $L \cdot min^{-1}$	
Auxiliary Gas Flow	0.5 $L \cdot min^{-1}$	
Central Tube Diameter	2 mm	

RF Power	1150 W	
Repeatability	5 times	
Analysis Time	Axial::	Radial
	15 sec	15 sec

RESULTS AND DISCUSSION

The results of the determination of element concentrations in Asfam ash by the ICP-OES method (μg/100 g), listed in descending order, are presented in table 2.

Table 2.
Results of determining the content of chemical elements in "Asfam" food additive by ICP-OES method.

№	Element	Emission Wavelength, nm	Determined Amount, μg/100 g	Standard Deviation, μg/100 g	Relative Standard Deviation, %
1.	K*	766.490	2011191.51	17238	0.9
2.	Ca*	393.366	593994.01	6358	1.1
3.	Mg*	279.553	105239.03	787	0.7
4.	P	185.942	66219.28	145	0.2
5.	Na*	589.592	52635.53	741	1.4
6.	Sn	189.989	7031.28	26	0.4
7.	Fe	259.940	4307.62	20	0.5
8.	Al	396.152	2108.19	14	0.7
9.	Sr	407.771	1845.18	72	3.9
10.	Si	251.611	1591.77	17	1.1
11.	Mn	257.610	993.57	3	0.3
12.	Ba	455.403	990.17	10	1.0
13.	Zn	213.856	898.32	6	0.7
14.	B	249.773	622.69	4	0.6
15.	Cr	283.563	615.76	6	1.0
16.	Cu	324.754	564.44	6	1.1
17.	Ni	221.647	376.03	4	1.1
18.	Li	670.776	109.77	1	0.9
19.	Mo	202.030	73.81	6	8.1
20.	Ti	334.941	67.86	3	4.4
21.	V	309.311	38.89	3	7.7
22.	Sc	361.384	20.90	1	4.8
23.	Zr	343.823	14.89	1	6.7
24.	Cd	228.802	14.72	1	6.8
25.	Sm	363.429	84.06	14	16.7
26.	Nd	378.425	76.09	14	18.4
27.	Hf	339.980	29.42	4	13.6
28.	Pb	220.353	26.54	6	22.6
29.	Ta	268.517	22.60	18	79.6
30.	As	189.042	17.66	17	96.3
31.	Er	323.058	15.05	3	19.9
32.	Th	283.231	14.63	8	54.7
33.	Ir	224.268	10.67	2	18.7
34.	Tm	342.508	8.81	2	22.7
35.	La	333.749	8.61	1	11.6
36.	Be	313.042	8.20	1	12.2
37.	Lu	261.542	5.69	1	17.6
38.	Hg	184.950	5.54	1	18.1
39.	Tb	350.917	4.72	1	21.2

40.	Cs	852.113	<LOD*	-	-
41.	Te	238.578	<LOD	-	-
42.	U	367.007	<LOD	-	-
43.	Sb	206.833	<LOD	-	-
44.	Pt	265.945	<LOD	-	-
45.	In	325.609	<LOD	-	-
46.	Os	225.585	<LOD	-	-
47.	Rh	343.489	<LOD	-	-
48.	Tl	190.856	<LOD	-	-
49.	Se	196.090	<LOD	-	-
50.	Rb	214.383	<LOD	-	-
51.	Bi	223.061	<LOD	-	-
52.	Re	227.525	<LOD	-	-
53.	Co	238.892	<LOD	-	-
54.	W	239.709	<LOD	-	-
55.	Ru	240.272	<LOD	-	-
56.	Au	242.795	<LOD	-	-
57.	Ge	265.118	<LOD	-	-
58.	Ga	294.364	<LOD	-	-
59.	Nb	309.418	<LOD	-	-
60.	Yb	328.937	<LOD	-	-
61.	Gd	335.047	<LOD	-	-
62.	Ag	338.289	<LOD	-	-
63.	Pd	340.458	<LOD	-	-
64.	Ho	345.600	<LOD	-	-
65.	Y	371.030	<LOD	-	-
66.	Eu	381.967	<LOD	-	-
67.	Pr	390.844	<LOD	-	-
68.	Dy	400.045	<LOD	-	-
69.	Ce	413.765	<LOD	-	-

Note: * Emission detection of Mg, Ca, Na, and K elements was performed using the radial method, while emission detection of the other elements was carried out using the axial method;

** <LOD – result is below the limit of detection.

According to the determined amounts of the elements presented in Table 2, they can be divided into 4 groups. The first group consists of the first 5 macroelements: K, Ca, Mg, P, and Na. The amounts of these elements in the "Asfam" food additive are 2–3 orders of magnitude higher than those of the other detected elements, accounting for 0.052% to 2.01% (Figure 1).

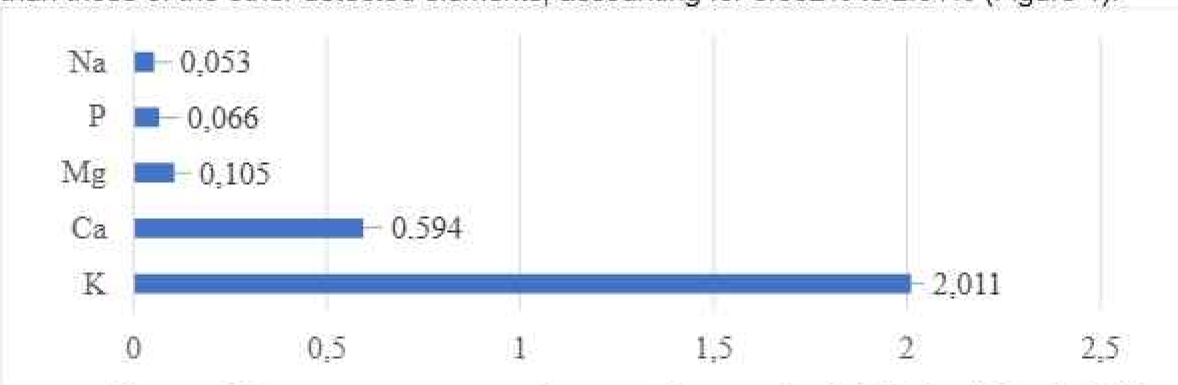

Figure 1. Percentage content of macroelements in the "Asfam" food additive (g/100 g).

It is evident from figure 1 that potassium and calcium are the most abundant macroelements in the "Asfam" food additive. Potassium (K) is the main intracellular cation and plays a role in maintaining water-electrolyte balance in the body, normal functioning of the heart and muscles, as well as transmission of nerve impulses [8]. Potassium stabilizes the contraction rhythm of the heart and regulates cardiac activity.

Potassium deficiency causes heart rhythm disturbances (arrhythmias), muscle weakness, and general fatigue. **Calcium (Ca)** is the most abundant mineral in the body, with approximately 99% of it stored in bones and teeth. In addition to being essential for the strength of bones and teeth, calcium plays an important role in muscle contraction, regulation of heart rhythm, blood clotting, and transmission of nerve impulses [2, 9]. Calcium deficiency leads to symptoms such as osteoporosis (bone fragility), muscle spasms, and heart rhythm disturbances. **Phosphorus (P)** is also present in bones and teeth alongside calcium, making up about 1% of the body's mineral content. It is a component of DNA and RNA, an integral part of ATP molecules responsible for energy production, and participates in the structure of cell membranes [10, 11]. Phosphorus deficiency can result in muscle weakness, fatigue, and bone softening (osteomalacia).

We classified 19 elements from tin (Sn) to cadmium (Cd) into the second group. This group mainly consists of biogenic microelements essential for the human body. It is worth noting that the amounts of these elements in the studied food additive are sufficient, ranging from 0.01 mg to 7.03 mg per 100 g (Figure 2). The relative standard deviation of the analysis for these elements and the macroelements does not exceed 10%, indicating a very high accuracy in the determination of the first 24 elements listed in the table.

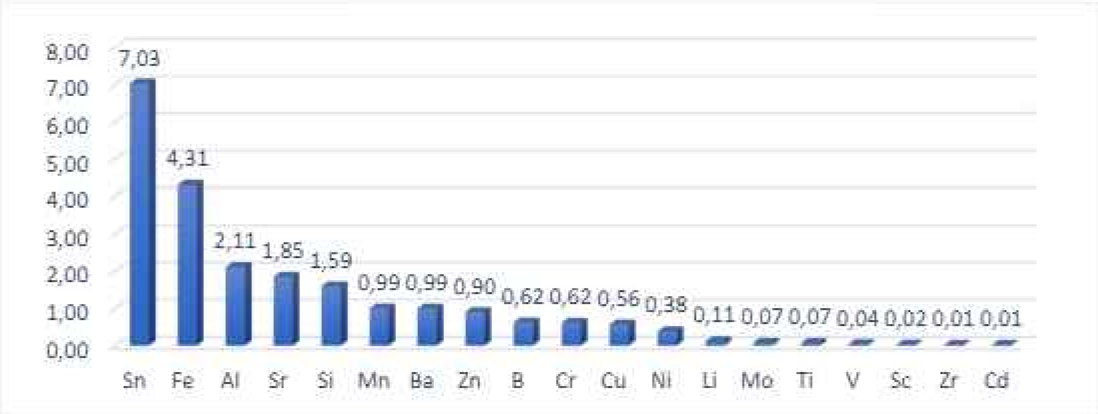

Figure 2. Content of biogenic microelements in the "Asfam" food additive, mg/100g.

It is evident from Figure 1 that the amounts of tin, iron, aluminum, and strontium among the biogenic microelements in the studied food additive are significantly high. According to the World Health Organization (WHO), the safe daily limit for tin is 2 mg/kg of body weight. For example, for a 70 kg person, this corresponds to approximately 140 mg. Currently, the evidence regarding the benefits of dietary tin intake for the human body remains inconclusive [12].

Iron (Fe) plays a crucial role in the transport and storage of oxygen in the body. It is a component of hemoglobin and myoglobin molecules. Additionally, iron participates in the activity of certain oxidative enzymes, facilitating oxygen exchange processes within cells. Iron deficiency leads to anemia, fatigue, decreased concentration, and weakened immunity [13].

The analysis error for the 15 elements from Sm to Tb (group 3) listed in Table 2 is relatively high, with relative standard deviations ranging from 10% to 100%. The main reason for this is the very low concentrations of these elements in the "Asfam" food additive. This results in relatively large experimental errors, which can be explained by the fact that the small analytical signals of these low-concentration elements are close to the instrument noise levels.

The amounts of 30 elements from Cs to Ce (group 4) in the "Asfam" food additive were extremely low, and their analytical signals were below the detection limit of the ICP-OES equipment. Therefore, it was not possible to determine the quantities of these elements.

The content of harmful and toxic heavy metals and arsenic in the "Asfam" food additive, as determined by us, is compared in Table 3 with the permissible limits established by the regulatory document (MH) [14], clause 10.7, for plant-based biologically active additives (dry teas).

Table 3. Determined and maximum permissible levels of heavy metals and arsenic in the "Asfam" food additive according to regulatory standards

Element	Permissible limit according to MH [14], mg/100 g (max)	Determined amount, mg/100 g	Relative to the maximum limit set by MH
Hg	0.010	0.006 ± 0.001	1.67 marta kam
Pb	0.600	0.026 ± 0.006	23.1 marta kam
Cd	0.100	0.014 ± 0.001	7.14 marta kam
As	0.050	0.018 ± 0.017	2.78 marta kam

As shown in Table 3, the amounts of heavy metals and toxic arsenic in the "Asfam" food additive are practically 1.67 to 23.1 times lower than the permissible limits.

CONCLUSION

The "Asfam" food additive, based on the composition of mandarin and kiwi fruit peels, allowed for the accurate determination of 39 out of 69 chemical elements using the ICP-OES method. This food additive was found to be rich not only in essential macroelements such as K (2.01%), Ca (0.59%), Mg (0.11%), P (0.07%), and Na (0.05%), but also in biogenic microelements including Sn, Fe, Al, Sr, Si, Mn, Ba, Zn, B, Cr, Cu, Ni, Li, and Mo. Furthermore, the amounts of heavy metals and toxic arsenic in the "Asfam" food additive were found to be significantly lower than the permissible limits. Among the macroelements, potassium, calcium, and magnesium, as well as microelements such as iron, strontium, manganese, and zinc, are present in sufficient quantities. This indicates that the "Asfam" food additive holds promising potential for use in modern medicine and traditional healing practices for the prevention and treatment of various conditions related to deficiencies of these elements, including cardiovascular and bone diseases, anemia, nervous and muscular system disorders, and inflammation of internal organs.

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