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Iron Content in Fruits, Vegetables, Herbs and Spices Samples Marketed in Sarajevo, Bosnia and Herzegovina

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Abstract

Iron deficiency anaemia is one of the major health problems that affects cognitive performance, physical capacity, immune status, and reproductive performance. The iron content in 35 food samples (fruits, vegetables, herbs, and spices) marketed in Sarajevo, Bosnia and Herzegovina was determined. The iron content in the fruits and vegetables was determined using FAAS spectrometry, and in the herbs and spices samples by UV/Vis spectrophotometry. Experimentally determined content was: fruits (2.91–39.27 mg kg^{-1}), vegetables (6.33–107 mg kg^{-1}), herbs (135–962 mg kg^{-1}), and spices (59.00–918 mg kg^{-1}). Daily intakes for different plant samples were also calculated. The food samples were arranged by iron concentration in the following descending order: herbs and tea > spices > vegetables > fruits. The results from this study were compared with previously published data. The obtained values are in the area of common values. The iron content and the factors that increase its bio-availability can help in the selection of proper foods to be included in the daily diet.

Keywords

Iron, fruits, vegetables, herbs, spices, FAAS, UV/Vis

1 Introduction

It is well known that a balanced diet is essential for good health. Consequently, the nutritional value of foods is a very important aspect that should be considered, particularly, with respect to metal intake, such as Fe, Ca, Mg, K, Na, Se, Mn, Cu, Cr, and Zn.[1] Deficiency of Fe in the body is very common, although, Fe is one of the most abundant elements in the Earth's crust. Iron is a component of haemoglobin present in red blood cells in the human body, and conveys oxygen throughout the body.[2] The absorption of dietary Fe is a complex process which has been well investigated. Dietary Fe consists of elemental Fe, and either heme or non-heme Fe.[3] It has several vital functions in the body, including oxygen supply, keeping a healthy immune system, and energy production. Iron overdose is associated with symptoms of nausea and vomiting, dizziness, diarrhoea, joint pain, and liver damage. Iron toxicity has an adverse effect on the cardiovascular system and various metabolic functions.[4]

Fruits and vegetables are rich sources of minerals, vitamins, and fibres, and have beneficial antioxidant effects. Fruits and vegetables are part of the daily diets in many households forming an important source of minerals and vitamins required for human health.[5] *Bhuvaneswari et al.*[6] suggested that foods, like apples, common figs, and ground nuts could be included in the diet, because they not only contain a good amount of Fe, but also ascorbic acid. Ascor-

bic acid has been reported as a powerful enhancer of non-heme Fe absorption, and it has been shown to reverse the inhibiting effect of, *e.g.*, calcium.[6]

Spices and herbs are sources of many bioactive compounds that can improve digestion, metabolism processes, as well as food flavour. They can also contain some undesirable and harmful components, *e.g.*, micotoxins, heavy metals, pesticides, and polycyclic carbohydrate residues.[7] Beside water, tea and herb tea are the most widely consumed beverages because of their health benefits and aroma.[8] A World Health Organization (WHO) survey indicated that about 70–80 % of the world population relies on non-conventional medicine, mainly from herbal sources, in their primary healthcare.[9,10] Various reports have discussed the potential health implications of trace metals in tea, particularly since it is known to accumulate trace metals.[11]

Spices are a group of esoteric food adjuncts that have been in use for thousands of years to enhance the foods sensory quality.[12] While a few dozen different spice plants are of global importance, many more are used locally in the regions of their natural occurrence as condiments.[7] These spice ingredients impart characteristic aroma, flavour, or colour and piquancy to foods.[12] Still, spices could represent an important part of the dietary source of trace elements. A further relevant aspect is consumer safety, since some of these spices could be loaded up to a toxic level with elements to improve aspects such as colour or taste.[13]

In this work, the iron content of the following plants was determined: fruits (apple, blueberry, cranberry, fig, grape-

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fruit (red), grapes (red), grapes (white), nectarine, orange, and pineapple); vegetables (eggplant, beetroot, broccoli, paprika (red), potato, spinach, and zucchini); herbs (black and green tea (*Camellia sinensis*), chamomile (*Matricaria chamomilla*), elder (*Sambucus nigra*), mint (*Mentha piperita*), nettle (*Urtica dioica*), rosehip (*Rosa canina*), thyme (*Thymus vulgaris*)), and spices (basil (*Ocimum basilicum*), black pepper (*Piper nigrum*), dill (*Anethum graveolens*), ground red paprika (*Capsicum annuum*), minced garlic (*Allium sativum*), oregano (*Origanum vulgare*), parsley (*Petroselinum crispum*), rosemary (*Rosmarinus officinalis*), safflower (*Carthamus tinctorius*), turmeric (*Curcuma longa*)).

2 Experimental

2.1 Materials and methods

All samples were collected from different markets in Sarajevo, Bosnia and Herzegovina. Samples of fresh vegetables and fruits were collected randomly in sufficient quantities (2 kg) to provide representative samples. The samples were washed with tap water and rinsed with Milli-Q water to remove any soil particles attached to the plant surfaces. Samples were cut into small pieces and air-dried for two weeks, then powdered, sieved, and stored in plastic bags for iron analysis.

Iron in the fruit and vegetable samples was extracted following the acid digestion procedure: About 2 g of air-dried plant sample was placed into a porcelain crucible. The samples were incinerated in a muffle furnace at 470 °C for 3 h. The ash was digested by adding 10 cm^3 of mixture of concentrated HNO_3 and concentrated HCl (ψ = 2 : 1), and 1 cm^3 of H_2O_2 (φ = 30 %) was also added. After evaporation, the residue was passed through a blue band filter paper. The digest was diluted to 50 cm^3 with Milli-Q water. Iron content of commonly consumed fruits and vegetables was determined by FAAS (AA240FS, Varian, Australia).

Iron in spices and herbs samples was extracted following the acid digestion procedure: About 2 g of crushed and homogenized plant sample was placed into a porcelain crucible. The samples were incinerated in a muffle furnace at 450 °C for 30 min. The ash was digested by adding 4 cm^3 of HCl (c = 10 mol dm^{-3}). The solution was heated at 90 °C until complete dissolution of the sample. The residue was passed through a blue band filter paper. The digest was diluted to 25 cm^3 with Milli-Q water. Iron content in herbs and spices was determined by UV/Vis spectrophotometry (Carry 50, Varian, Australia), thiocyanate method.

All the chemicals and reagents were of analytical grade and purchased from Merck (Germany). Standard solution of iron was also provided by Merck. Milli-Q water was used throughout. All of the volumetric glassware was of A grade, and soaked in nitric acid (φ = 10 %) for 12 h and rinsed with Milli-Q water before use. The sample and blank analyses were performed in triplicate, and the standard deviation was calculated. The value of the detection limit (LOD) for Fe was 0.04 µg cm^{-3}. Spiked samples were used to test the methods at varying concentrations of analyte, and the percent recovery was calculated. The acceptable recovery of known additions was obtained (89–104 %).

Concentration of iron is expressed as the mean value (mg kg^{-1})±SD of three subsamples collected from the same source.

2.2 Daily intake

Humans need a certain daily intake of minerals. Recommended Daily Intake, RDI value, recommended by experts and agencies for a normal adult population for iron is 15 mg.[1]

2.2.1 Daily intake for fruit and vegetables

Daily intake (mg kg^{-1} day^{-1}) is calculated based on the assumptions that:

1) Body weight is 60 kg, and

2) Daily intake of fruits and vegetables is 200 g.

Daily intake (mg kg^{-1} day^{-1}) = metal concentrations in fruits and vegetables × 200/1000/60.[14,15,16]

2.2.2 Daily intake for spices

Daily intake (mg kg^{-1} day^{-1}) is calculated based on the assumptions that:

1) Body weight is 60 kg, and

2) Daily intake of spices is 1.5 g.

Daily intake (mg kg^{-1} day^{-1}) = metal concentrations in spices × 1.5/1000/60.[17,18,19]

3 Results and discussion

In this work, the Fe content was determined in the investigated plants (fruits, vegetables, herbs and spices) bought from local markets in Sarajevo. The recommended daily intake of Fe ranges from 0.27 mg for infants, 10 mg for children 4–8 years of age, 11 mg for adolescents to 8 mg for men, and 18 mg for women.[19] Some of the plant-based foods are a good source of Fe but they may contain Fe absorption inhibitors or promoters. Depending on whether the food contains promoters or inhibitors, the bioavailability of Fe differs. The Fe content in different fruits, vegetables, herbs, and spices samples marketed in Sarajevo is presented in Table 1.

Table 1 – Iron content (mg kg⁻¹ ± SD) in different fruits, vegetables, herbs, and spices samples marketed in Sarajevo and literature values

Tablica 1 – Sadržaj željeza (mg kg⁻¹ ± SD) u različitim uzorcima voća, povrća, ljekovitog bilja i začina s tržišta u Sarajevu i literaturne vrijednosti

Category Kategorija	Category items Pojedinačni nazivi u kategoriji	Iron content /mg kg⁻¹ ± SD Sadržaj željeza /mg kg⁻¹ ± SD	Calculated average daily iron intake /mg kg⁻¹ day⁻¹ Izračunati dnevni unos željeza /mg kg⁻¹ dan⁻¹	Iron content, literature values /mg kg⁻¹ Sadržaj željeza, literaturne vrijednosti /mg kg⁻¹
Fruits Voće	Apple Jabuka	4.10±1.76	0.014	8.49,[5] 9.2,[6] 14.2[20]
	Blueberry Borovnica	39.27±6.11	0.131	28.12[5]
	Cranberry Brusnica	29.12±3.55	0.097	52.02[5]
	Fig Smokva	2.91±1.59	0.001	15.91,[5] 13.2[6]
	Grapefruit (red) Grejpfrut (crveni)	8.54±4.47	0.028	13.50,[5] 2.6[21]
	Grapes (red) Grožđe (crveno)	11.91±4.45	0.040	39.54[5]
	Grapes (white) Grožđe (bijelo)	3.58±1.47	0.012	12.50[5]
	Nectarine Nektarina	3.91±2.68	0.013	22.91[5]
	Orange Naranča	18.85±1.55	0.063	61.50,[5] 2.0[21]
	Pineapple Ananas	9.00±3.18	0.030	12.16,[5] 2.8[21]
Vegetables Povrće	Eggplant Patlidžan	31.84±1.15	0.104	3.16,[2] 17.6[20]
	Beetroot Repa	105±7.40	0.349	113.31[5]
	Broccoli Brokula	21.75±7.02	0.072	48.99,[5] 4.7[21]
	Paprika (red) Paprika (crvena)	8.99±6.71	0.030	17.81[5]
	Potato Krumpir	27.06±0.37	0.090	22.91,[5] 19.1[20]
	Spinach Špinat	107±0.67	0.356	22.73,[2] 9.8,[6] 257[20]
	Zucchini Tikvica	6.33±3.30	0.021	28.61[5]
Herbs & tea Ljekovito bilje i čaj	Black tea Crni čaj (*Camellia sinensis*)	562±101	–	21.3–37.6,[22] 154.9[23] 96.5,[24] 243[25] 176.0–946.2[26]
	Green tea Zeleni čaj (*Camellia sinensis*)	427±27.3	–	231,[24] 135[25] 242–589[27]
	Chamomile Kamilica (*Matricaria chamomilla*)	135±19.2	–	188.3–581.3[4] 153,[24] 521[25]
	Elder Zova (*Sambucus nigra*)	458±30.6	–	79.3,[24] 15.53–214.6[28]
	Mint Menta (*Mentha piperita*)	306±62.1	–	150.57–821.02,[4] 532,[24] 281[25] 275.6–354.6[29] 293[30]
	Nettle Kopriva (*Urtica dioica*)	962±92.8	–	105,[24] 999[25]
	Rosehip Šipak (*Rosa canina*)	674±89.5	–	89,[24] 27.5,[25] 150.3–230.0[31]
	Thyme Timijan (*Thymus vulgaris*)	857±57.9	–	120.75–764.51[4] 822,[24] 440[25]

Table 1 – (continued)
Tablica 1 – (nastavak)

Category Kategorija	Category items Pojedinačni nazivi u kategoriji	Iron content / mg kg⁻¹ ± SD Sadržaj željeza /mg kg⁻¹ ± SD	Calculated average daily iron intake / mg kg⁻¹ day⁻¹ Izračunati dnevni unos željeza / mg kg⁻¹ dan⁻¹	Iron content, literature values / mg kg⁻¹ Sadržaj željeza, literaturne vrijednosti / mg kg⁻¹
Spices Začini	Basil Bosiljak (*Ocimum basilicum*)	112±65.1	0.003	185.73−1101.23[4] 552−625[30] 156.1−259.2[32]
	Black pepper Crni papar (*Piper nigrum*)	213±24.1	0.005	85.73,[2] 200−984[30] 11.16−19.00[32] 482.28[33]
	Dill Kopar (*Anethum graveolens*)	254±49.1	0.006	345.7[34]
	Ground red paprika Mljevena crvena paprika (*Capsicum annuum*)	343±27.2	0.008	39.9−659[30] 22.9−34.5[32] 70.90[35]
	Minced garlic Mljeveni češnjak (*Allium sativum*)	59.00±2.71	0.001	54.6−69.3[30] 58.6[36]
	Oregano Origano (*Origanum vulgare*)	918±44.3	0.023	155.74−420.52[4] 459−619[30] 116.8−197.1,[32] 152[37]
	Parsley Peršin (*Petroselinum crispum*)	313±73.0	0.008	81.26−605.5[4] 189−381,[30] 72.6−78.6[32] 561.79[33]
	Rosemary Ružmarin (*Rosmarinus officinalis*)	118±16.6	0.003	431.93,[23] 42.9−107.7,[32] 19.4,[36] 149[38]
	Safflower Šafranika (*Carthamus tinctorius*)	866±22.9	0.022	940.6−1663[39] 255.3[40]
	Turmeric Kurkuma (*Curcuma longa*)	103±12.0	0.003	256.33,[33] 159.6[40]

3.1 Iron content in fruits

Fruits are an important source of iron and offer advantages over dietary supplements. In daily diet, fruits have been strongly associated with reduced risk of some forms of cancer, heart disease, stroke, and other chronic ailments.[41] As may be seen from Table 1, the iron content in the fruit samples ranged from 2.91 to 39.27 mg kg⁻¹. The highest iron concentration was found in blueberry, followed by cranberry, orange, grapes (red), pineapple, grapefruit (red), apple, nectarine, grapes (white), and fig. According to the results of iron in the fruits, and comparing these results with recommended daily iron intake, it seems that consumption of 200 g of blueberry should provide the total daily iron need for men. Comparison of our results with those of other authors showed that the iron content was similar or lower.

3.2 Iron content in vegetables

Vegetables constitute essential diet components by contributing proteins, vitamins, iron, calcium, and other nutrients that are in short supply.[42] The iron content in the vegetable samples ranged from 6.33 to 107 mg kg⁻¹. The concentration of iron varied between different vegetable samples. The samples were arranged by iron concentration in the following descending order: spinach > beetroot > eggplant > potato > broccoli > paprika (red) > zucchini. For example, according to the results of iron content in vegetables and comparing these results with recommended daily iron intake, consumption of about 200 g of spinach should provide the total daily iron need for women.

3.3 Iron content in herbs and tea

Herbal remedies are widely used for the treatment of various illnesses. They often contain highly active pharmacological components, including minerals and trace metals.[4] The WHO limit for iron in medicinal herbs has yet to be established. The results of the determination of iron differed between analysed herbs and tea samples. As may be seen from Table 1, the highest level of iron was 962 mg kg⁻¹, and the lowest level was 135 mg kg⁻¹. The herbs and tea samples were arranged by iron concentration in the following descending order: nettle > thyme > rosehip > black tea > elder > green tea > mint > chamomile. Comparison of our results with those of authors from other countries
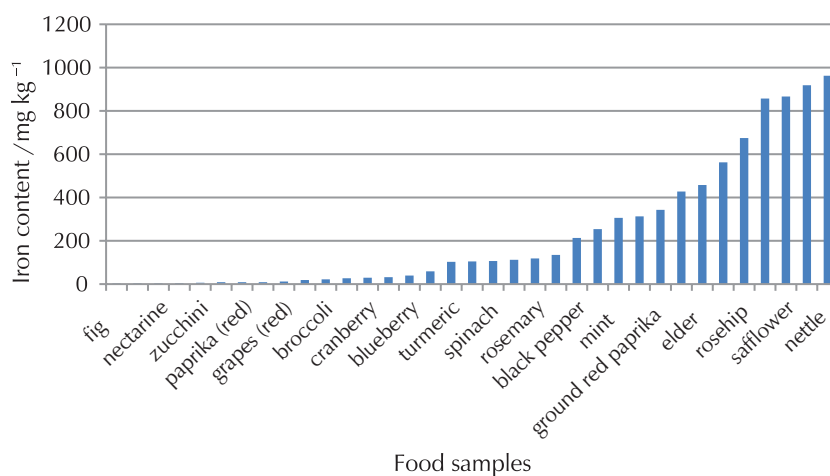
Fig. 1 – Comparison of iron content in different food samples
Slika 1 – Usporedba sadržaja željeza u različitim uzorcima hrane

showed that the iron content was similar. Among the four food groups investigated in this work, herbs and tea were observed to contain the highest iron content.

3.4 Iron content in spices

The results of iron analysis in the selected spices samples are presented in Table 1. The observed range of iron in the current study was found between 59 and 918 mg kg^{-1}. The spices were arranged by iron concentration in the following descending order: oregano > safflower > ground red paprika > parsley > dill > black pepper > rosemary > basil > turmeric > minced garlic. The comparison of our results regarding iron content in the spices with those of other authors showed good agreement.

Fig. 1 shows the comparison of iron content in different food products.

4 Conclusion

Some of the plant-based foods are a good source of Fe, but they may contain Fe absorption inhibitors or promoters. Depending on whether the food contains promoters or inhibitors, the bioavailability of Fe differs. The iron content of 35 food samples was determined by FAAS spectrometry and UV/Vis spectrophotometry. Overall, the results showed that Fe was present in varied concentrations in fruits, vegetables, herbs, tea and spices commonly consumed in Bosnia and Herzegovina. The food samples were arranged by iron concentration in the following descending order: herbs and tea > spices > vegetables > fruits. The results were compared with the available literature data. The obtained values are in the area of common values. The iron content and the factors that increase its bioavailability could help in selecting the proper foods to be included in the daily diet.

List of abbreviations
Popis kratica

FAAS – flame atomic absorption spectrometry
– plamena atomska apsorpcijska spektrometrija

LOD – limit of detection
– granica detekcije

RDI – recommended daily intake
– preporučeni dnevni unos

SD – standard deviation
– standardna devijacija

UV/Vis – ultraviolet/visible spectrometry
– ultraljubičasta/vidljiva spektrometrija

WHO – World Health Organization
– Svjetska zdravstvena organizacija

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SAŽETAK

Sadržaj željeza u voću, povrću, ljekovitom bilju i začinima s tržišta u Sarajevu, Bosna i Hercegovina

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Anemija zbog nedostatka željeza, jedan je od glavnih zdravstvenih problema, a utječe na kognitivne sposobnosti, fizički kapacitet, imunološki status i reproduktivnu sposobnost. Utvrđen je sadržaj željeza u ukupno 35 uzoraka hrane (voće, povrće, ljekovito bilje i začini) s tržišta u Sarajevu u Bosni i Hercegovini. Sadržaj željeza u voću i povrću određen je FAAS spektrometrijom, a u uzorcima ljekovitog bilja i začina UV/Vis spektrofotometrijom. Utvrđen je sljedeći sadržaj: voće ($2{,}91 - 39{,}27$ mg kg^{-1}), povrće ($6{,}33 - 107$ mg kg^{-1}), ljekovito bilje ($135 - 962$ mg kg^{-1}) i začini ($59{,}00 - 918$ mg kg^{-1}). Također su izračunati dnevni unosi za različite uzorke biljnog materijala. Prema koncentracijama željeza uzorci su raspoređeni u sljedećim serijama: ljekovito bilje > začini > povrće > voće. Rezultati ovog istraživanja uspoređeni su s prethodno objavljenim podatcima. Dobivene vrijednosti nalaze se u području literaturnih podataka. Sadržaj željeza i čimbenici koji povećavaju njegovu bioraspoloživost mogu pomoći u odabiru odgovarajuće hrane za svakodnevnu prehranu.

Ključne riječi
Željezo, voće, povrće, ljekovito bilje, začini, FAAS, UV/Vis

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