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ANALYSIS OF IRON CONTENT OF SELECTED VEGETARIAN FOOD ITEMS IN DUBAI, UAE

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Abstract: Iron is the fourth most abundant element in the earth but its deficiency in the body is very common. It is a component of hemoglobin present in the ubiquitous red blood cells (RBCs) in the body that conveys oxygen throughout the body. Without iron, the body cannot make healthy RBCs, thus it is an essential micro mineral. Non-vegetarians are rarely a victim of iron deficiency as their diet consists of meat through which they consume proteins like haemoglobin and myoglobin directly in the unaltered form. Vegetarians are more susceptible to the deficiency of iron as they consume non-heme iron which needs to be altered before it can be absorbed by the body. Consequently, there is a need to measure the amount of iron in the vegetarian food products to estimate which food sources are rich in iron, so that they may be consumed during iron deficiency. In the present study, 25 vegetarian food samples belonging to six different food categories were analysed. The food samples were bought from the local retail shops and supermarkets of Dubai. The iron content was determined using the spectrophotometric technique of analysis which works on the principle of the Beer-Lambert law. The results showed that spices and condiments had the maximum contribution towards the dietary iron content whereas the vegetables had the minimum contribution.

Introduction

Malnutrition arising from dietary deficiency of critically important mineral micronutrients such as iron (Fe) is a serious problem affecting nearly half of the world's population (Shobana et al. 2013). Iron deficiency, even in absence of anemia, can cause fatigue and reduce work performance (Zimmermann and Hurrell 2007). The absorption of dietary iron is a complex process which has been well investigated. Dietary iron consists of elemental iron, and either heme or non-heme iron (Zhu et al. 2010). These forms differ markedly in the molecular mechanisms of their absorption and bioavailability. Thus, from a nutritional point of view, both the total amount of iron and the form of iron in food are significant (Schonfeldt and Hall 2011). Calcium inhibits the absorption of haem and non-haem iron, which occurs during the initial uptake of iron into the enterocyte (Hurrell and Egli 2010). Young women are at particular risk of iron deficiency due to losses from menstruation and childbirth

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(Toxqui et al. 2013). Menstruation is the most significant factor that increases a female's risk of iron deficiency (Denic and Agarwal 2007). A research group has observed that the recommended dietary allowance (RDA) of 18 mg/day of iron for women was not easily reached even when the volunteers consumed 5 portions of red meat and 2 portions of poultry/week (Navas et al. 2008). Reasons for the gap between the Reference Dietary Intakes for iron and actual iron intake have been hypothesised as lack of affordability, poor access to fresh foods, and lack of knowledge and awareness about nutrition (Ball et al. 2004). It is important to monitor fresh foods for their nutritional value. There are several methods to analyse the nutrient concentration in foods. For higher concentrations (more than 1 mg kg−1) of iron forms, the colorimetric methods have been used . In the present work, thiocyanate spectrophotometric technique had been used.

Materials and Methods

Materials

Food samples and categorization

25 vegetarian food samples belonging to different food groups were bought from the local supermarkets of Dubai. The food samples were categorized as shown in Table 1 . vegetables, 2 nuts, 6 spices and condiments, 3 beverages and 5 cereals and pulses were selected for the analyzed in the specified form. They were local food items of Dubai or belonged to the local brands.

S.No	Category	Items taken in the category
1	Vegetables	• Eggplant • Red tomato, • Spinach, • Summer squash • Cabbage
2	Nuts	• Peanuts • Almonds (dry)
3	Chocolates and Related items	• Dark chocolate 70% cocoa • Milk chocolate • Dates
4	Spices and Condiments	• Green chillies • Soy Sauce • Green cardamom • Bay leaves • Cumin seeds • Black pepper

5	Beverages	• Green tea leaves, crushed • Instant coffee powder • Drinking chocolate powder
6	Cereals and Pulses	• Brown bread • Pasta • White rice, long grain • Kidney beans • Yellow lentils

Table 1: Selected food samples and their categorization

Preparation of stock solution

Three stock solutions were made ready before the experiment and were stored in five 500 mL neatly labeled standard flasks. Firstly, the 0.001 M $FeCl_3$ stock solution was prepared by adding approximately 0.162 g of $FeCl_3$ in 500 mL distilled water followed by the addition of 5 mL concentrated HCl. The contents were diluted to 1 L and were mixed well before being transferred to the standard flask. This solution was only used for calibration purposes and was discarded after that. The 1.5 M KSCN solution was prepared by adding approximately 36.375 g of KSCN in 500 mL distilled water. The contents were mixed well before being transferred to the standard flask. This solution was the basis of the colorimetry involved in the analysis and was used till the end of the experiment. The 2 M HCl solution was prepared by adding 170 mL of concentrated HCl to 500 mL distilled water and diluting the solution to 1 L with distilled water. The contents were mixed well before being transferred to the standard flask. This solution was used for dilution purposes and served as the blank in the spectrophotometric analysis.

Apparatus and principle

Thiocyanate spectrophotometry was carried out using a Lambda 25 UV/VIS Spectrophotometer of the PerkinElmer make. The spectrophotometer worked on the principle of the Beer-Lambert law and was operated in the visible range of the spectrum. The colorimetric reagent used for the analysis was potassium thiocyanate, for which the λ_{max} value obtained was 480 nm. The basic reaction when thiocyanate reacts with iron(III) is as follows:

$Fe^{3+}(aq) + 6SCN^{-}(aq) \leftrightarrow [Fe(SCN)_6]^{3-}(aq)$

The thiocyanate complex, $[Fe(SCN)_6]^{3-}$ had a deep red colour and its intensity was directly related to the concentration of solution. The spectrophotometric analysis was used for its simplicity, convenience and availability in the institute.

Calibration curve:

Seven standard solutions were prepared each having a molarity of $0.5x10^{-4}$ M, $1x10^{-4}$ M, $1.5x10^{-4}$ M, $2x10^{-4}$ M, $2.5x10^{-4}$ M, $3x10^{-4}$ M and $4x10^{-4}$ M. The first solution was prepared by diluting 0.5 mL of 0.001 M $FeCl_3$ solution with 9.5 mL of 2 M HCl solution. Similarly, the corresponding solutions are made by diluting 1 mL, 1.5 mL, 2 mL, 2.5 mL, 3 mL and 4 mL of 0.001 M $FeCl_3$ solution to 10 mL by 2 M HCl solution. After this, 5 mL of 1.5 M KSCN was added to each of the solution and mixed by swirling the test tubes. This step diluted the 10 mL solution to 15 mL causing the concentration to decrease by $2/3^{rd}$ of its original molarity value. Thus, the values read by the spectrophotometer were for two-thirds of the actual concentration. After adding KSCN, the absorbance was measured immediately because absorbance value can be affected as the colour of the solution fades within 15-20 minutes. 2M HCl was used as the blank. Using these solutions, the concentration vs absorbance curve was plotted as shown in Fig. 1, using the concentrations as enlisted in Table 2.

Original concentration ($Mx10^4$)	Concentration being measured ($Mx10^4$)	Absorbance
0.5	0.33	0.1849
1	0.67	0.4381
1.5	1	0.5478
2	1.3	0.7779
2.5	1.7	1.1221
3	2	1.2484
4	2.68	1.6847

Table 2: Concentration and absorbance values

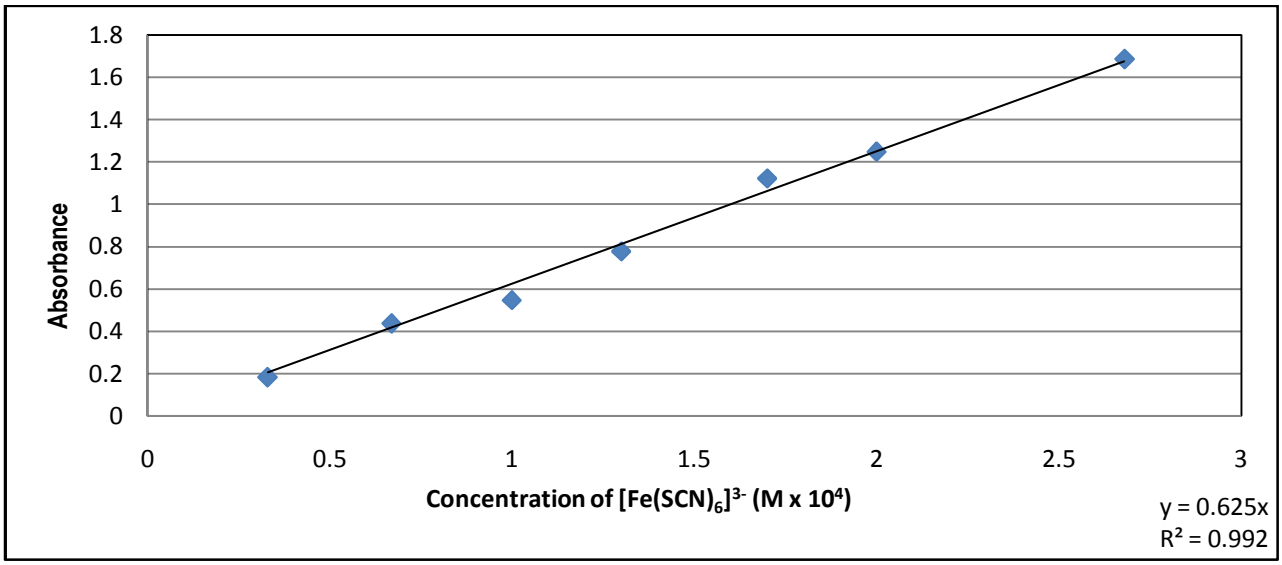

Fig. 1 The calibration curve using the standard solutions

Ashing of the samples:

1-15 g of the edible portion of the food samples was weighed. They were finely chopped for the purpose of ashing. The weighed samples were finely chopped and heated in a stainless steel vessel over a hot induction plate at 200-240ºC. This step was carried out in a well ventilated room. The heating time varied depending on the amount of sample and the rate at which the sample burned to ash. The samples were heated till a grayish ash was observed and then they were powdered using a mortar and pestle. After the samples were cooled, they were transferred to a small beaker of 100 mL capacity and the iron (III) in the ash was dissolved in 10 mL-30 mL of 2 M HCl. The ash solution was stirred using a glass stirring rod for about 5 minutes and then filtered.

Analysis of the samples:

5 mL of the filtered sample was transferred to a test-tube and then 5 mL of 1.5 M KSCN was added. The mixture was stirred by swirling the test tube. The absorbance was measured without delay as the colour of the solution faded within 15-20 minutes. The solution concentration was halved by adding 5 mL of KSCN, thus, the concentration values were multiplied by 2 during the calculations. The 2 M HCl solution served as the blank. The absorbance values were measured for all 25 samples.

Results and Discussion:

The absorbance values were determined by the spectrophotometer and the concentration was found out by interpolation or extrapolation using the calibration graph prepared earlier. After

the calculations, the iron content determined in the different food samples was tabulated in an increasing order of amount of iron present as shown in Table 3. The same representation is shown in a bar graph (Fig. 2) to aid visualization.

S.No	Category	Items taken in the category	Iron content (mg Fe/100 g of food sample)
1	Vegetables	• Eggplant • Red tomato, • Spinach, • Summer squash • Cabbage	0.316 0.293 2.273 0.819 0.764
2	Nuts	• Peanuts • Almonds (dry)	4.315 3.976
3	Chocolates and Related items	• Dark chocolate 70% cocoa • Milk chocolate • Dates	6.514 1.355 1.414
4	Spices and Condiments	• Green chillies • Soy Sauce • Green cardamom • Bay leaves • Cumin seeds • Black pepper	0.979 1.381 12.285 34.33 64.3 8.573
5	Beverages	• Green tea leaves, crushed • Instant coffee powder • Drinking chocolate powder	7.271 4.704 1.219
6	Cereals and Pulses	• Brown bread • Pasta • White rice, long grain • Kidney beans • Yellow lentils	4.067 3.432 4.417 2.019 6.008

Table 3 The iron content in different food samples

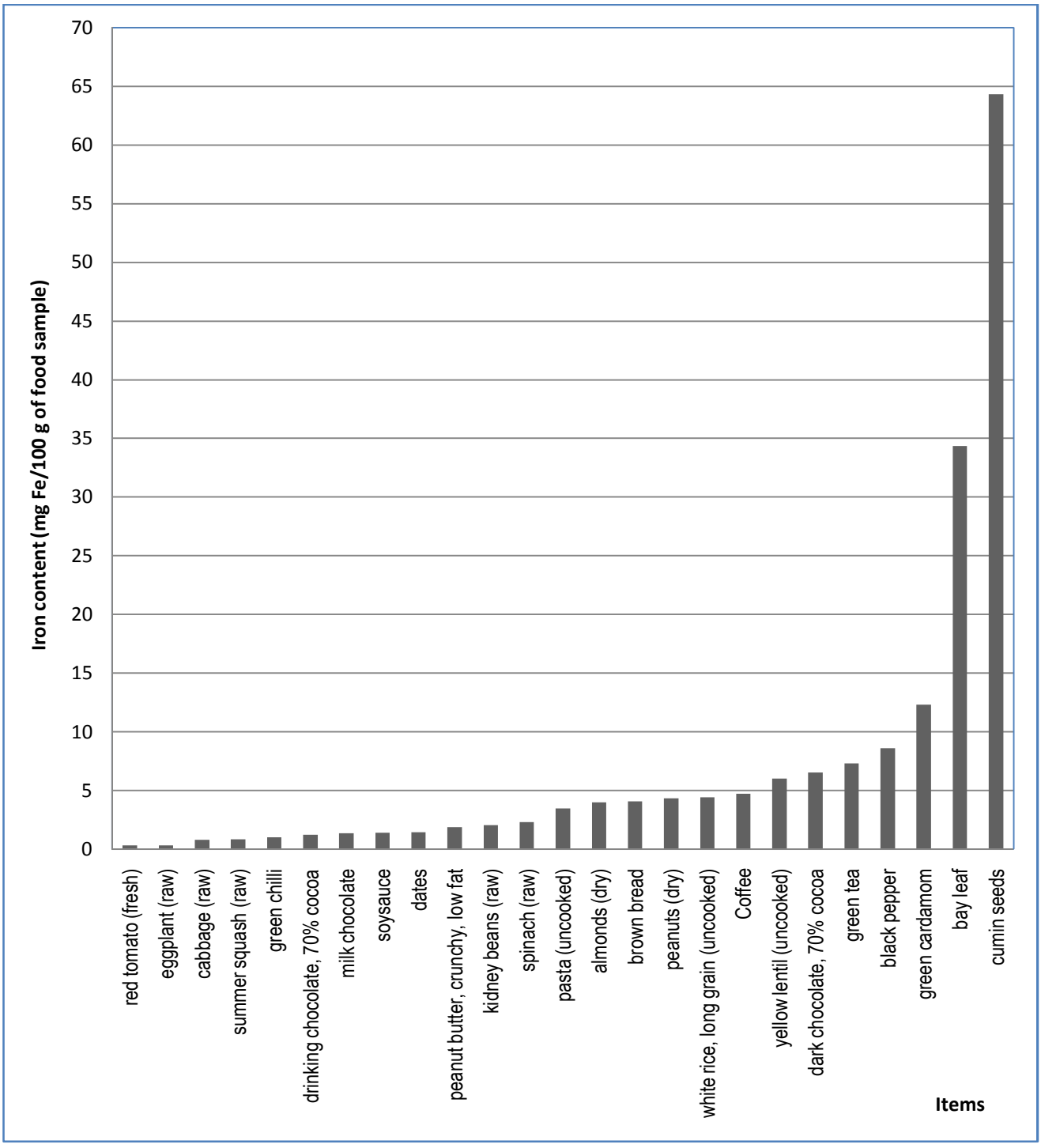

Fig. 2 A visual comparison of iron content in different food samples

Among the six food groups, the spices and condiments were observed to contain the maximum iron content. Bay leaves and cumin seeds were found to contain exceptionally high quantities of iron, 34.33 and 64.3 mg/ 100 g of food sample, respectively. Beverages, nuts and cereals and pulses also contained an appreciable amount of iron. Among beverages, green tea was found to contain the highest iron content of 7.271 mg/100 g of sample. Among

nuts, both peanuts and almonds contained high iron content with values of 4.315 and 3.976 mg/g of sample. Among cereals, brown bread contained the highest iron content with a value of 4.067 mg/g of sample and among pulses, yellow lentils had a good iron content of 6.008 mg/ g of sample. Among chocolates and related products, milk chocolate contained low amounts of iron but dark chocolate contained a huge amount of 6.514 mg iron/ g of sample. The vegetables were seen to have the lowest iron content, except spinach which had a comparatively higher iron content of 2.273 mg/ g of sample.

The contributions of dietary iron of the various food groups are summarized by the pie chart given in Fig. 3. Vegetables had the lowest iron content among the six food groups followed by chocolates, cereals and pulses, nuts, beverages, and spices and condiments in increasing order of their contribution towards the dietary iron content.

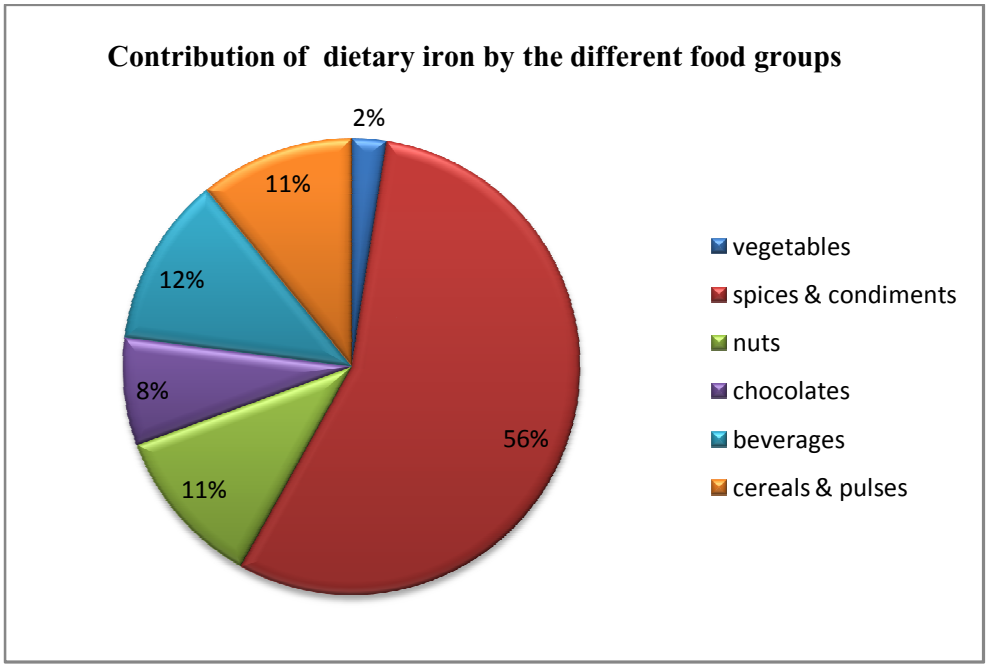

Fig. 3 A pie chart showing the contributions of dietary iron by the six food groups

Conclusions

The iron content in a total of 25 food samples was analyzed using the thiocyanate spectrophotometric technique. The main aim was to determine the iron content in the local vegetarian food samples to ensure the mineral quality and quantity of vegetarian food items in Dubai. The results showed a good quantity of iron in the spices and the condiments followed by beverages, nuts, cereals and pulses and chocolates and related products. The least iron was available in the local vegetables. An extremely high quantity of iron was observed in

cumin seeds and bay leaves, which are whole spices, regularly accompanied with food as seasonings to enhance the taste of meals served in India. Vegetarians are usually susceptible to low iron intake as they are dependent on non-heme sources of iron, which are not readily absorbed and they do not usually contain the large amount of iron as is offered by the meat or heme sources. Vegetarians may improve their dietary iron intake, according to the Recommended Daily Intake (RDI) of iron, by following a diet containing iron-rich vegetarian food sources like green leafy vegetables (spinach), nuts, pulses (lentils and kidney beans). Beverages like coffee and green tea also contain high iron quantities but they would not be recommended much as their increased intake may decrease the absorption of non-heme iron in the body.

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