Determination of Calcium in Mashhad City Tap Water by Flame Atomic Absorption Spectrometry

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Summary: Calcium in drinking water is one of the sources of calcium that may contribute significantly to the daily calcium intake. In this study, the samples of tap water were randomly taken from five zones of Mashhad city. Calcium concentration was determined by flame atomic absorption spectrometry (FAAS) technique. The precision of the method was evaluated. The CV% of 6 replicate determinations at 5 µg/ml Ca was 4.2 in one day and 4.5, among 6 consecutive days. The recovery of spiked samples (98.7%) also showed that the proposed method is reliable for the determination of amounts of calcium in water samples. The mean of calcium in tap water in the city of Mashhad was 52.61±12.91 (SD) µg/ml. At present, the amount of calcium in Mashhad tap waters is within the national standard. However, due to the climate and environmental changes, determination of calcium in tap water of Mashhad in different seasons is recommended.

Key words: Calcium, Drinking water, Tap water, FAAS

Introduction

Calcium is an essential element that a human body needs for numerous functions, such as building and maintaining the bones, blood clotting, transmitting of the nerve impulses and regulating heart's rhythm. Nearly all (99%) calcium in a human body is stored in bones and teeth. The remaining one percent is found in the blood and other tissues. The body gets calcium by resorption phenomena from the bones when blood levels of calcium fall too low. Physiologically, the resorbed calcium is replaced later. However, this does not always take place, and calcium deficiency can increase the risk of bone disorders, such as osteoporosis [1]. Adequate calcium intake is essential for achieving normal bone mass and prevention of osteoporosis [2-7]. One way to prevent osteoporosis is to consume enough calcium in order to compensate the Ca uptake from the bones [8]. Milk and dairy products are a convenient source of calcium for many people. Calcium can also be found in dark green leafy vegetables, dried beans legumes, and calcium-fortified juice [9–11]. Another way to increase calcium intake is to drink enriched mineral water [12, 13]. It is important that we should be aware of the mineral content of tap water in our regions. Drinking water may contribute significantly to the daily calcium intake. The issue of the adequate amount of water intake is not clear. There is a common perception that healthy adults should drink six to eight glasses (1.4–1.9 L) of water a day [14].

Different methods for determination of calcium in water were reported. A traditional method in the quality control of calcium is titrometry [15]. The concentration of calcium in natural waters is determined by spectrophotometric method [16], single-use optical sensor [17], capillary electrophoresis [18] and ion chromatography [19-21]. However, flame atomic absorption spectrometry (FAAS) is one of the most reliable and extensively used techniques for the determination of various elements including Ca with high precision and accuracy. This technique is remarkable for its selectivity, speed and low operational cost [22].

The tap water in Mashhad is provided from two rivers and 300 wells in margins of the city. Drinking water comes from either surface water (rivers and streams) or ground water sources (mainly wells), and this natural environment allows calcium to enter the water sources [23, 24]. Calcium enters the water as either calcium carbonate from limestone or as calcium sulfate from other mineral deposits.

The current study presents the calcium concentrations in Mashhad city tap waters by flame atomic absorption spectrometry (FAAS) technique.

Results and Discussion

Calculations of the percentage of recommended intake supplied by each water source were based on a healthy adult recommended daily intake (RDI) of 1000 mg of calcium and the average water intake of 1.7 L [4, 14].

We surveyed the calcium concentration in tap water in Mashhad to determine their contribution to the recommended calcium requirements. Calcium

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concentrations in different areas of Mashhad were shown in table 2. We found variability in tap water calcium concentrations. In Mashhad, tap water calcium concentrations varied from 24.8 µg/ml in Seyyedi area, to 79.8 µg/ml in Imam Reza Street. The mean±SD calcium concentration was 52.61± 12.91µg/ml, and the percentage of RDI of calcium satisfied by 1.7 L per day varied from 4.2 to 13.6%, with an average of 8.9%. There was no statistically significant difference between areas. On the other hand, with respect to the maximum allowable concentration of calcium in drinking water according to the Iranian national standard institute guideline (200 ppm), the amount of calcium in Mashhad tap waters is within the standard range. Therefore, at present, tap water in Mashhad could be a major contributor of calcium to the diet.

Table-1: Determination of calcium in five spiked water samples for recovery test.

Area water sample	Added (µg/ml)	Measured (µg/ml)	Recovery (%)
1	0	49.6	96.0
	100	143.6	
11	0	56.7	96.3
	100	151.0	
21	0	64.3	97.3
	10	160.0	
31	0	46.5	102
	10	149.1	
41	0	39.9	102
	10	143	
		Mean	98.7

Data shown are mean values each sample run in triplicate.

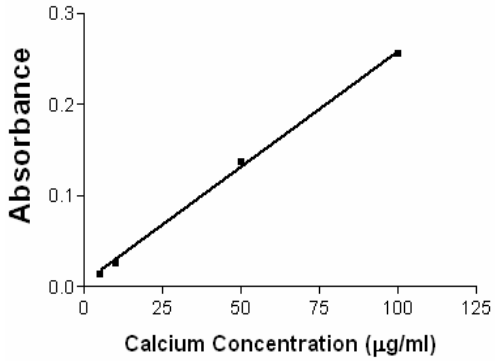

Chart 1: The calibration curve for calcium standards.

$y = 0.0025x + 0.0024$, $R^2 = 0.9984$.

The CV% of 6 replicate determinations at 5 µg/ml Ca was 4.2 in one day and was 4.5, among 6 consecutive days.

With regard to the concentration of calcium, the water samples obtained from Mashhad tap water was within the range of moderately hard water. There is no health risk associated with the hardness of drinking water. However, when hard water is heated calcium deposits or 'lime scale' might form. This can affect household appliances such as kettles, dish washers, washing machines and some heating systems. For this purpose, softening of water should be performed as required. Therefore, softening of drinking water in Mashhad city is not recommended. At present, the amount of calcium in Mashhad tap waters is within the national standard. However, due to the climate and environmental changes, determination of calcium in tap water of Mashhad in different seasons, is recommended.

Table-2: The calcium concentrations of drinking waters in different areas of Mashhad.

Area No.	calcium (µg/ml)	Percentage of calcium (RDI)	Area	Calcium (µg/ml)	Percentage of calcium (RDI)
1	49.6	8.4	26	56.0	9.5
2	38.6	6.6	27	59.4	10.1
3	47.5	8.1	28	78.7	13.4
4	55.7	9.5	29	79.8	13.6
5	44.6	7.6	30	51.5	8.7
6	49.1	8.3	31	46.5	7.9
7	53.8	9.1	32	38.4	6.5
8	49.5	8.4	33	41.1	7.0
9	48.5	8.2	34	37.9	6.4
10	49.5	8.4	35	54.0	9.2
11	56.7	9.6	36	45.6	7.7
12	47.3	8.0	37	67.8	11.5
13	38.5	6.5	38	71.1	12.1
14	43.5	7.4	39	51.2	8.7
15	53.5	9.1	40	71.9	12.2
16	44.6	7.6	41	39.9	6.8
17	46.7	7.9	42	48.6	8.3
18	55.5	9.4	43	24.8	4.2
19	51.5	8.7	44	40.1	6.8
20	44.7	7.6	45	46.3	7.9
21	64.3	10.9	46	45.1	7.7
22	77.6	13.2	47	77.0	13.1
23	63.7	10.8	48	52.8	9.0
24	76.3	13.0	49	41.8	7.1
25	77.0	13.1	50	35.5	6.0

Data shown are mean values each sample analyzed in triplicate.
Mean ± SD of calcium concentration of whole areas is 52.61±12.91 µg/ml.

Experimental

Sampling and Instrumentation

After dividing the city into five zones, based on the geographical map of Mashhad, 10 random samples were taken from each zone. After flowing the water from the pipe for two minutes, 20 cc water was collected in precleaned containers. The number of samples was 50 and each sample was analysed in triplicate.

A Perkin-Elmer Scientific atomic absorption spectrometer Model 3030 (flame) was used for all measurements. The hallow cathode lamp for calcium was used as the light source. According to the manufacturer recommendation the analytical wave-

length, spectral bandwidth and lamp current were 422.7 nm, 0.7 nm and 15 mA respectively. The flame composition was acetylene and air.

Reagents

All chemicals were of analytical grade. Standard stock solution of calcium, 1.0 mg/ml, was prepared by dissolving an appropriate amount of CaO in diluted hydrochloric acid (1:1). Calcium ion standard solution was diluted daily in order to obtain a working standard solution of calcium (100 µg/ml). High-purity water was used throughout the sample preparation, and all the solutions were stored in precleaned polypropylene containers. The materials and vessels used for analysis were kept in 10% hydrochloric acid for at least 24 h and subsequently washed four times with ultra-high-quality water before use.

Analysis of Water Samples

The reliability of the method was evaluated by spiking calcium into five samples randomly. The recovery results were shown in Table 1. The recovery of spiked samples showed that the proposed method is sensitive and reliable for the determination of amounts of calcium in water samples. The precision of the method was also evaluated. The CV% of 6 replicate determinations at 5 µg/ml Ca was 4.2 in one day and was 4.5, among 6 consecutive days. The calibration curve for calcium had an R^2 value of 0.9984, and is therefore also a good representation of the linearity Beer's Law plot (chart 1). The results of tap water analyses are shown in Table 2.

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