Research Article

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Determination of essential and non-essential element contents of drinking water and baby water for infant’s nutrition

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Abstract: In this study, essential (Ca, Cr, Cu, Fe, K, Mg, Na, P, Zn), and non-essential (Al, Ni, Pb) element contents of the drinking and baby water samples which are sold in the local market and tap water samples in Istanbul were examined. It was determined that elements of Cr, Cu, Fe, P, Zn, Al, and Ni were below detection limits in all water samples. Among the non-essential elements analyzed in water samples, Pb was the only detected element.

At the same time, the percentages that meet the daily element requirements of infants were also calculated. As a result of the evaluations made, there is no significant difference in infant nutrition between baby waters and other drinking waters in terms of the element content.

Keywords: baby water, essential elements, non-essential elements, element consumption

1 Introduction

The consumption of essential nutrients with adequate quantities and types is significant for the healthy growth of infants. Also, the appropriate amount of fluid intake is vital for infants because of body temperature regulation, transportation of nutrients, cell metabolism, and normal kidney function (United States Department of Agriculture Food and Nutrition Service, 2009). Breast milk is the main fluid source for infants especially for the first six months (Ministry of Health of New Zealand, 2008). However, in some cases, infants cannot be breastfed and substitutes like infant formulas are crucial for both 0-6 months and 6-12 months old infants to get sufficient nutrients. Therefore, the ingredients and the quality of the breast milk substitute foods and water, which is mainly used for the preparation of infant formula, gain importance. Some studies investigate the elemental composition and daily intake amounts of some essential elements. Mir-Marqués et al. (2015) obtained different commercial baby foods containing meat, fish, vegetable, and fruit from the Spanish market. The mineral composition was determined for 14 elements (Al, Ba, Cd, Ca, Cr, Cu, Fe, K, Mg, Mn, Mo, Ni, Sr, Zn) and adequate mineral intake values were calculated. Silva et al. (2013) assessed the amount of particular essential elements of Fe, Zn, Cu, and Mn in baby foods to evaluate their bioaccessibility by the human body for the infants. Pandelova et al. (2012) calculated the infant intakes of some non-essential and the essential elements in the most consumed baby foods in Europe including infant formula, solid foods, and beverages (SFB).

Besides these baby foods, water consumption is very significant for baby nutrition. The drinking water may contain some elements which are known or suspected to be essential for humans. Due to the consumed water affects the total trace element and mineral intake of infants, its content should be known. The investigated water types and their element contents in some literature studies are given in Table 1.

In recent years, drinking water produced for infants and called “baby water” is consumed as well as other bottled and tap water. The nutrient properties of water are related to the consumption and affected by the behavioral factors and environmental conditions (Olivares and Uauy, 2005). The nutritionally important minerals in water are
Table 1: Published studies about essential and non-essential element concentrations of water in literature

| Water types                  | Essential elements (mg/L) | Non-essential elements (mg/L) | Reference                  |
|------------------------------|----------------------------|--------------------------------|----------------------------|
|                              | Ca  | Cr  | Cu  | Fe  | K   | Mg  | Na | P  | Zn | Al | Ni | Pb | Reference                  |
| North American                |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Surface water sources         | 34.00 | ± |     | 21.00 | ± | 10.00 | 35.00 | ± | 52.00 | 20.00 | 91.00 | ± | Azoulay et al., 2001          |
| Ground water sources          |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Riyadh                       |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Eastern Riyadh               | 52.00 | ± | 0  | 4.60 | ± | 57.00 | 0.00784 | ± | 24.00 | 13.00 | 67.00 | ± | Abed and Alwakeel, 2007       |
| Western Riyadh               | 9.60 | ± | 0  | 0.70 | ± | 11.50 | 0.00988 | ± | 24.00 | 13.00 | 67.00 | ± | Abed and Alwakeel, 2007       |
| Central Riyadh               | 39.50 | ± | 0  | 6.60 | ± | 26.00 | 0.00419 | ± | 24.00 | 13.00 | 67.00 | ± | Abed and Alwakeel, 2007       |
| Peninsular Malaysia           |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Riyadh                       |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| A                            | 8.40 | ± | 0.02 | 0.50 | ± | 1.00 | 22.40 | ± | 5.30 | 0.18 | 0.06 | ± | Azrina et al., 2011          |
| B                            | 17.00 | ± | 0.02 | 0.20 | ± | 2.50 | 14.00 | ± | 5.30 | 0.18 | 0.06 | ± | Azrina et al., 2011          |
| C                            | 17.00 | ± | 0  | 2.50 | ± | 7.00 | 20.00 | ± | 5.30 | 0.18 | 0.06 | ± | Azrina et al., 2011          |
| North American                |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Spring waters                | 18.00 | ± | 0  | 8.00 | ± | 4.00 | 0.09 | ± | 3.20 | 1.10 | 4.30 | ± | Azoulay et al., 2001          |
| Mineral waters               |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| 100.00 | ± | 22.00 | 18.00 | ± | 4.00 | 0.09 | ± | 3.20 | 1.10 | 4.30 | ± | Azoulay et al., 2001          |
| 125.00 | ± | 42.00 | 335.00 | ± | ± |     |     |    |    |    |    |    |                                |
| European                     |     |     |     |     |     |     |     |     |    |    |    |    |                                |
| Low mineralization water     | 60.00 | ± | 16.00 | 13.00 | ± | 262.00 | 64.00 | ± | 139.00 | 37.00 | 797.00 | ± | Azoulay et al., 2001          |
| Moderate mineralization water | 60.00 | ± | 16.00 | 1.51 | ± | 59.00 | 20.00 | ± | 59.00 | 20.00 | 153.00 | ± | Azoulay et al., 2001          |
| High mineralization water    | 60.00 | ± | 16.00 | 1.51 | ± | 59.00 | 20.00 | ± | 59.00 | 20.00 | 153.00 | ± | Azoulay et al., 2001          |
selenium (Se), sodium (Na), fluorine (F), potassium (K), molybdenum (Mo), boron (B), magnesium (Mg), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), and chromium (Cr). The lack or excess of these elements may cause adverse influences on the infant’s body (Molska et al., 2014).

In spite of the fact that there are lots of studies about the element content of baby food such as infant formulas and fruit juices, there was no study about the element content of baby waters and comparison with drinking waters and tap water. The purpose of this study is the determination and comparison the element content of baby, drinking, and tap water samples. Also, it is aimed to calculate the daily main intake (DMI) of analyzed elements in water samples for both 1-6 months and 6-12 months old infants. Additionally, the obtained DMI values are compared with the element requirements of infants depend on their gender and weight.

2 Results and discussion

2.1 Validation of analytical method

Table 2 shows the results of analytical method validation in terms of detection and quantification limits, correlation coefficients, and coefficient of variance measurements by ICP-OES. \( R^2 \) of the calibration curves for these elements were higher than 0.999.

The stability of the detector response was investigated by analyzing a multi-element Standard solution with moderate concentration with each batch (ten samples). The relative standard deviation and the values of CV% were less than 10% for all the analyte elements.

2.2 Instrumental analysis results

The concentrations of essential and non-essential elements in samples are given in Table 3. Essential elements of Ca, K, Mg, Na, and non-essential elements of Pb were found in all water types with different concentrations. On the other hand, Cr, Cu, Fe, P, Zn, Al, and Ni were below the detection limit in all samples.

Ca concentrations varied between 9.067-32.125 mg/L for baby water, 4.710-13.765 mg/L for drinking water. However, for city water, Ca content was measured as 1.931 mg/L which was the lowest Ca in analyzed samples. When water samples were examined, it was seen that baby

| Element | Limits of detection (mg/L) | Limits of quantification (mg/L) | Correlation coefficient (R²) | Coefficient of variance (CV%) |
|---------|----------------------------|-------------------------------|-----------------------------|-----------------------------|
| Ca      | 0.0015                     | 0.0049                        | 0.9999                      | 2.886                       |
| Cr      | 0.0006                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| Cu      | 0.0006                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| Fe      | 0.0015                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| K       | 0.0006                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| Mg      | 0.0015                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| Na      | 0.0006                     | b.d.l.                         | 0.9999                      | b.d.l.                      |
| P       | b.d.l.                      | b.d.l.                         | b.d.l.                      | b.d.l.                      |
| Zn      | b.d.l.                      | b.d.l.                         | b.d.l.                      | b.d.l.                      |
| Al      | b.d.l.                      | b.d.l.                         | b.d.l.                      | b.d.l.                      |
| Ni      | b.d.l.                      | b.d.l.                         | b.d.l.                      | b.d.l.                      |
| Pb      | b.d.l.                      | b.d.l.                         | b.d.l.                      | b.d.l.                      |

*b.d.l. below detection limit.
The concentrations of essential and non-essential elements in water samples

| Elements   | Conc. (mg/L) |
|------------|--------------|
|            | BW-1 | BW-2 | BW-3 | DW-1 | DW-2 | DW-3 | DW-4 | CW-1 |
| Essential  |       |      |      |      |      |      |      |      |
| Ca         | 32.125| 9.067| 19.195|13.765|12.170|11.570| 4.710| 1.931|
| Cr         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Cu         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Fe         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| K          | 0.13  | 0.246| 0.074| 0.987| 0.487| 0.037| 0.182| 0.181|
| Mg         | 14.34 | 1.762| 5.130| 2.359| 2.759| 1.924| 1.030| 0.398|
| Na         | 1.426 | 1.425| 0.203| 1.212| 0.706| 1.844| 2.093| 1.197|
| P          | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Zn         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Non-essential |       |      |      |      |      |      |      |      |
| Al         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Ni         | b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.| b.d.l.|
| Pb         | 0.0315| 0.016| 0.030| 0.028| 0.009| 0.018| 0.014| 0.025|

* b.d.l.: below detection limit.

were used. The results were estimated for both female and male infants. According to results, for 0-6 months old infants, maximum Na intake percentages were calculated as 1.3779% (DW-4) for male infants and 1.2558% (DW-4) for female infants. Maximum Ca (12.6894% for male and 11.5650% for female) and Mg (37.7620% for male and 34.4160% for female) intake percentages were found in BW-1. Maximum K intake percentages were calculated as 0.1948% and 0.1776% in DW-1 for male and female infants, respectively.

When the results of 6-12 months old infants compared with 0-6 months old infant results, it was observed that maximum intake percentages were obtained in the same water samples for all essential elements due to their higher element concentration.

In Table 5, daily main intake values of Pb based on gender and age of infants and PTDI values are presented. PTDI values were calculated for the ages of 1st, 6th, and 12th months according to the infant weights which are given in Table 6. When results were compared, it was seen that daily main intake values of Pb for each water sample were below PTDI and were not at a harmful level for the infant body. Also, it was observed that Pb concentration was not dependent on water types because it showed a difference according to brands.

### 3 Conclusion

In this study, essential (Ca, Cr, Cu, Fe, K, Mg, Na, P, Zn), and non-essential (Al, Ni, Pb) element contents of the drinking and baby water samples which are sold in the local market and tap water samples in Istanbul were examined. According to obtained results, it was...
Table 4: Daily intake percentages of essential elements with the consumption of baby water (%)

| Water types | 0-6 months |   |   |   |   |
|-------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|             | Na          | Ca              | K               | Mg              |
|             | Male Male   | Female Male     | Female Male     | Male Male Female| Female Male     |
|             | Min Max     | Min Max         | Min Max         | Min Max         | Min Max         | Min Max         | Min Max         |
| BW-1        | 0.523 0.939 | 0.499 0.856     | 7.068 12.689    | 6.746 11.565    | 0.014 0.026     | 0.014 0.023     | 21.032 37.762   | 20.076 34.416   |
| BW-2        | 0.523 0.938 | 0.499 0.855     | 1.995 3.581     | 1.904 3.264     | 0.027 0.049     | 0.026 0.044     | 2.584 4.640     | 2.467 4.229     |
| BW-3        | 0.074 0.133 | 0.071 0.122     | 4.223 7.582     | 4.031 6.910     | 0.008 0.015     | 0.008 0.013     | 7.525 13.510    | 7.183 12.313    |
| DW-1        | 0.444 0.798 | 0.424 0.727     | 3.028 5.437     | 2.891 4.955     | 0.109 0.195     | 0.104 0.178     | 3.460 6.212     | 3.303 5.662     |
| DW-2        | 0.259 0.465 | 0.247 0.423     | 2.677 4.807     | 2.556 4.381     | 0.054 0.096     | 0.051 0.088     | 4.046 7.264     | 3.862 6.620     |
| DW-3        | 0.676 1.214 | 0.645 1.106     | 2.545 4.570     | 2.430 4.165     | 0.004 0.007     | 0.004 0.007     | 2.821 5.065     | 2.693 4.616     |
| DW-4        | 0.767 1.378 | 0.733 1.256     | 1.036 1.861     | 0.989 1.696     | 0.020 0.036     | 0.019 0.033     | 1.510 2.711     | 1.441 2.471     |
| CW-1        | 0.439 0.788 | 0.419 0.718     | 0.425 0.763     | 0.406 0.695     | 0.020 0.036     | 0.019 0.033     | 0.585 1.049     | 0.558 0.956     |

| Water types | 6-12 months |   |   |   |   |
|-------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|             | Na          | Ca              | K               | Mg              |
|             | Male Male   | Female Male     | Female Male     | Male Male Female| Female Male     |
|             | Min Max     | Min Max         | Min Max         | Min Max         | Min Max         | Min Max         | Min Max         |
| BW-1        | 0.305 0.391 | 0.278 0.366     | 9.761 12.541    | 8.896 11.738    | 0.015 0.019     | 0.013 0.017     | 15.105 19.407   | 13.766 18.164   |
| BW-2        | 0.304 0.391 | 0.277 0.366     | 2.755 3.5394    | 2.511 3.313     | 0.028 0.036     | 0.025 0.033     | 1.856 2.385     | 1.692 2.232     |
| BW-3        | 0.043 0.056 | 0.039 0.052     | 5.832 7.4934    | 5.316 7.014     | 0.008 0.011     | 0.008 0.010     | 5.404 6.943     | 4.925 6.499     |
| DW-1        | 0.259 0.322 | 0.236 0.311     | 4.182 5.3736    | 3.812 5.030     | 0.111 0.143     | 0.102 0.134     | 2.485 3.193     | 2.265 2.988     |
| DW-2        | 0.151 0.194 | 0.137 0.181     | 3.698 4.7510    | 3.370 4.447     | 0.055 0.071     | 0.050 0.066     | 2.906 3.733     | 2.648 3.494     |
| DW-3        | 0.394 0.506 | 0.359 0.474     | 3.516 4.5168    | 3.204 4.228     | 0.004 0.005     | 0.004 0.005     | 2.026 2.603     | 1.847 2.436     |
| DW-4        | 0.447 0.574 | 0.407 0.537     | 1.431 1.8387    | 1.304 1.721     | 0.021 0.026     | 0.019 0.025     | 1.084 1.393     | 0.988 1.304     |
| CW-1        | 0.256 0.328 | 0.233 0.307     | 0.587 0.7540    | 0.535 0.706     | 0.020 0.026     | 0.019 0.025     | 0.420 0.539     | 0.383 0.505     |
determined that elements of Cr, Cu, Fe, P, Zn, Al, and Ni were below detection limits in all water samples. The highest element concentration belonged to Ca in the samples and it was followed by Mg, Na, and K respectively. Among the non-essential elements analyzed in water samples, Pb is the only detected element. When baby waters, drinking waters, and tap water were investigated separately, it was seen that the content of the elements varied according to the water brands, not to the water types. For this reason, there is no clear distinction between the elemental contents of baby waters and drinking waters. In the study, when filtered tap water was analyzed as a control sample, it was observed that the content of Ca and K in packaged water was higher than tap water, but there was no significant difference in other elements in this comparison. At the same time, the percentages that meet the daily element requirements of infants were also calculated. When the results are examined, it was determined that the percentage of meeting daily requirements varies depending on the concentrations changes of the elements in a different brand of baby and drinking water. As a result of the evaluations made, it was ascertained that there is no significant difference for infant nutrition between baby waters and other drinking waters in terms of the element content. This study presents a new result for conscious consumption and infant health. Waters to be used by consumers should be categorized on a reliable brand basis, not an infant, drinking or tap water as they are on the market.

### Experimental

#### Preparation and supply of water samples

Three brands of baby water (BW) and four brands of drinking water (DW) samples were purchased from the local market in Turkey in August 2017. The waters were stored at ambient conditions (temperature, 24 ± 5°C; humidity, 45 ± 10%) in the original packings: 1 L (Brand 1-BW 1), 330 mL (Brand 2-BW 2), and 200 mL (Brand 3-BW 3) plastic bottle for baby water; 500 mL plastic bottle for drinking water.

The samples were used in the study for the determination of Na, Ca, K, Mg, Fe, Zn, P, Cu, Cr, Pb, Al, and Ni elements by Inductively coupled plasma optical

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**Table 5:** Daily main intake values of Pb based on gender and age of infants

| Month | 1st | 6th | 12th |
|-------|-----|-----|------|
|       | Males | Females | Males | Females | Males | Females |
| PTDI  | 15.714 | 15.000 | 28.214 | 25.714 | 36.786 | 33.929 |
| BW-1  | 13.860 | 13.230 | 24.885 | 22.680 | 31.973 | 29.925 |
| BW-2  | 7.040  | 6.720  | 16.240 | 15.200 | 30.450 | 28.500 |
| BW-3  | 12.100 | 11.550 | 21.725 | 19.800 | 27.913 | 26.125 |
| DW-1  | 3.740  | 3.570  | 6.715  | 6.120  | 8.628  | 8.075  |
| DW-2  | 7.920  | 7.560  | 14.220 | 12.960 | 18.270 | 17.100 |
| DW-3  | 6.270  | 5.985  | 11.258 | 10.260 | 14.464 | 13.538 |
| CW-1  | 10.780 | 10.290 | 19.355 | 17.640 | 24.868 | 23.275 |

**Table 6:** Water/free liquids required (WR) according to ages (Fluid Requirements for Children, 2019, available at: www.articles.complexchild.com/00037.pdf/)

| Age (month) | Reference weight (kg) | Water/free liquids required (WR) (mL) |
|-------------|-----------------------|--------------------------------------|
|             | Males | Females | Males | Females | Males | Females |
| 1           | 4.4   | 4.2     | 440   | 420     |
| 2           | 5.3   | 4.9     | 530   | 490     |
| 3           | 6.0   | 5.5     | 600   | 550     |
| 4           | 6.7   | 6.1     | 670   | 610     |
| 5           | 7.3   | 6.7     | 730   | 670     |
| 6           | 7.9   | 7.2     | 790   | 720     |
| 7           | 8.4   | 7.7     | 840   | 770     |
| 8           | 8.9   | 8.1     | 890   | 810     |
| 9           | 9.3   | 8.5     | 930   | 850     |
| 10          | 9.7   | 8.9     | 970   | 890     |
| 11          | 10.0  | 9.2     | 1000  | 920     |
| 12          | 10.3  | 9.5     | 1015  | 950     |
emission spectrometry (ICP OES). In addition to the supplied waters, the city water (CW) that was purified using the Rainbow Water Filter System was also analysed. No pre-treatment process was applied to the samples before ICP-OES analysis.

Preparation of the calibration sets

Standard solutions for measuring the elements Ca, Cr, Cu, Fe, K, Mg, Na, P, Zn, Al, Ni, and Pb by ICP-OES were prepared from mono-elemental stock solutions of 1000 mg L\(^{-1}\) (Merck, Darmstadt, Germany). Standard solutions were prepared in different concentrations by stock solutions diluted with Nitric acid 3‰ (v/v) (HNO\(_3\), 65%) (Merck chemicals (Merck KgaA, Darmstadt, Germany)) to ensure that the water samples were compatible with the elemental amounts.

A linear calibration algorithm analysis was used to check linearity in terms of correlation coefficients (R\(^2\)) for all elements. All analyses were performed in three replicates.

Elemental analysis of the water samples

Elemental analysis of water samples was performed with Perkin-Elmer Optima 2100 DV ICP-OES equipped with an AS-93 autosampler (PerkinElmer, CT, USA).

ICP-OES is a rapid and accurate elemental analysis technique for the determination and identification of minor and major elements. ICP-OES has lots of advantages in comparison to other spectral techniques. It provides high sensitivity for detecting and simultaneous determinations of several major and minor elements (Stojanovic et al., 2014).

The measurement conditions of these analyses were determined as follows a power of 1.45 kW, plasma flow of 15.0 L min\(^{-1}\), auxiliary flow of 0.8 L min\(^{-1}\), and nebulizer flow of 1 L min\(^{-1}\).

Based on the types on the market, the bottled waters were classified as follows: BW-1, BW-2, and BW-3 are baby waters, DW-1, DW-2, DW-3, and DW-4 are drinking waters. The city water was classified as CW-1.

Daily essential element intake percentages

Essential element intake percentages for infants between the months of 1-6 and 6-12 were calculated according to Eqs. 1 and 2:

\[
m = C \times WR
\]

\[
DMI = m \times 100 / AI
\]

where \(m\) is the element contents (mg) which is calculated according to water/free liquids requirement (WR) of infant based on their ages and gender (Table 2), \(C\) (mg/L) is the element concentration of water, \(AI\) is adequate intake values which are given in Table 3, and \(DMI\) is daily main intakes. Daily intake percentage (DIP) was also calculated using Eq. 3:

\[
DIP = DMI \times 100 / AI
\]

Babies have a bigger surface area to weight ratio when compared to adults and developmental levels are different. These are the parameters that cause the fluid
requirement of babies to differ from adults. In literature studies, it is seen that fluid requirements differ according to the expenditure which is proportional to the surface area. The Holliday-Segar formula is one of the various formulas used to calculate the liquid needs of infants and calculates liquid requirements based on weight.

According to this method an infant needs (Fluids and Electrolyte Management, 2019, available at: www.reliasmedia.com/articles/137306-fluids-and-electrolyte-management-part---fluids-dehydration-and-sodium-homeostasis/):

- 100 mL/kg/d for the first 10 kg of weight,
- 50 mL/kg/d for the second 10 kg of weight,
- 20 mL/kg/d for babies over 20 kg of weight.

Statistical analysis

Regression analysis was conducted using triplicate measurements of all samples and Statistica 8.0 computer programme (StatSoft Inc., Tulsa, USA) was used for the analysis. Analysis was performed for calculating average values and standard deviations of measurements.

The average values of the triplicate measurements for each sample were calculated using Eq. 4:

$$\bar{x} = \frac{1}{n} \sum_{i=0}^{n} x_i$$  \hspace{1cm} (4)

The standard deviation of the analysis results were calculated using Eq. 5:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=0}^{n} (x_i - \bar{x})^2}$$  \hspace{1cm} (5)

where $x$ is the average value of the sample, $x_i$ is the average value of the sample at the parallel $i$, $n$ is the number of parallel samples, and $s$ is the standard deviation.

Quality control

Limits of detection (LOD) and limits of quantification (LOQ) and relative standard deviations are used as validation parameters for analytical analysis methods. Replicate measurements of standard or sample solutions give information about results accuracy. In this study, detection limits of all elements used in the experiment were determined and the capability of the method according to validation results were calculated by replicate measurements results.

LOD and LOQ values were calculated from the results obtained by three and ten times the standard deviation results of the ten blank solutions (Khan et al., 2013). Solutions were prepared individually.

Percent coefficients of variance (CV%) are obtained by measuring the relative standard deviation of ten repeated replicates of one sample and it gives information about the precision of analysis. Relative standard deviations of analytical results below 15% are regarded as appropriate in terms of precision (Madeja et al., 2014).

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