Elemental Analysis of Some Table Sugars Produced In Iraq By Using Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) and X-Ray Fluorescence (XRF) Spectrometer

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Abstract— The sugar is the most commonly and old used materials in our daily life. Sugars are a white crystalline group of soluble carbohydrates that are sweet tasting in nature. Sugar molecules are classified as monosaccharides or disaccharides. Sucrose is commonly called table sugar and is a disaccharide. In this study, ten samples of table sugar produced by big companies in Iraq were investigated by using ICP-MS and XRF spectrometer methods. The elements in sugar samples by XRF analysis are Na, Cl, Ca, K, Mg, Si, Fe, Rh, Al, S, Cu, Zn, Zr, P. On the other hand the elements in sugar samples by ICP-MS analysis are Mg, Al, K, Ca, Mn, Fe, Ni, Zn, Sr, Ba. This is the first large-scale study in this field. It will be a guiding light for Industrial Sugar Production.

Keywords— Table sugar, Elemental Analysis, ICP-MS, XRF.

I. INTRODUCTION

White refined sugar is sucrose of a very high purity (>99.9 %) that is industrially produced from sugar beet or cane and commonly used for baking, cooking, and sweetening domestic food products and beverages or technologically applied to prepare other processed food and beverages [1]. Interest in the inorganic analysis of sugars exists in many fields of human activity and stems from different factors, as sugar plays a fundamental role in the diet of humans, with annual consumption in the range of 25–60 kg for adults. Therefore, determination of the elemental composition of sugar is important in nutrition studies [2]. On the other hand determination of the elemental composition of sugar can provide important information about its quality and safety. The elemental profile of sugar seems to be a useful fingerprint of the regions where it originates and the methods of pretreatment and processing [3]. An increasingly important aspect of sugar quality is to control the concentration of trace metals and to minimise sugar pollution by improving husbandry and processing practices [4]. Sugar is a material potentially useful for dosimetry in neutron therapy, hadron therapy, and radiation accidents [5].

In this study two multi elemental analytical techniques, inductively coupled plasma mass spectrometry (ICP-MS) and X-ray fluorescence analysis (XRF) were used for the analysis of the elemental composition of ten samples of table sugar from different Iraqi factories. Sugar samples were pretreated with different methods which are widely used in practice. A comparison was made not only between the concentrations obtained by the different methods, but also between the statistical conclusions derived from the processing of the experimental results. The statistical analysis demonstrated that statistically significant differences were observed between the two instrumental techniques.

II. EXPERIMENTAL AND COMPUTATIONAL METHODS

II.1. Instrumentation

The analyzes were carried out using inductive plasma-mass spectrometry (ICP / MS) and X-ray Fluorescence spectrometry (XRF) methods at Erciyes University Technology Research and Application Center. X-ray fluorescence spectra were obtained by spectrums of spectra using wave-length (WD / XRF) Panalytical Axios Advanced spectrometer and inductively coupled plasma-mass spectra (ICP-MS) using AGILENT 7500A model spectrometer.

II.2. Computing Details

Descriptive statistics test and normality test were performed using the statistical program of IBM-SPSS-22 (SPSS for Windows, Inc., Chicago, Illinois, USA) for the elements forming the table sugar. The maximum, minimum and standard deviations of the elements found in the structure of the tiles were obtained from the obtained data.

III. RESULTS AND DISCUSSION

Out of ten different companies of table sugar: Al safa Al dahabia, Aldahab, Al baghdady, Crystal, Zaher Albustan, Aletihad, Alful, Belady, Alaosra Alsaida, Babil, produced in Iraq, ICP / MS analysis was performed using elemental analysis. The results of the analysis are given in Table 1.
As shown in Table 1 the result of ICP-MS analysis in sugar samples, Mg, Al, K, Ca, Fe, Ni, Zn, Sr and Ba elements were detected with high sensitivity. When quantities of Mg element in the contents of the samples are listed (ppm) 1. sample 6.96538> 5. sample 6.81932> 6. sample 5.69578> 1. sample 5.35486> 2. sample 3.53416> 9. sample 2.45673> 7. sample 2.33200> 8. sample 1.88789> 4. sample 1.58874> 10. sample 1.25970 was detected. For Al element (ppm) 1. sample 6.28998> 5. sample 4.53920> 6. sample 4.08691> 2. sample 3.98420> 10. sample 3.76456> 9. sample 2.45673> 7. sample 2.33200> 8. sample 1.88789> 4. sample 1.58874> 10. sample 1.25970 was detected. For K element (ppm) 10. sample 7.13106> 1. sample 4.16526> 7. sample 3.53327> 6. sample 3.13652> 8. sample 2.86039> 5. sample 2.37148> 2. sample 1.96914> 4. sample 1.48961> 3. sample 1.02668> 9. sample 0.68173 was detected. For Ca element (ppm) 1. sample 40.4572> 4. sample 12.5320> 2. sample 11.6348> 3. sample 10.2752> 10. sample 9.88349> 5. sample 9.60418> 6. sample 5.19315> 7. sample 2.31091> 8. sample 1.87082> 9. sample 1.46153 was detected. For Mn element (ppm) 8. sample 1.24> 7. sample 0.52> 5. sample 0.44> 3. sample 0.426> 4. sample 0.28> 2. sample 0.27> 1. sample 0.15 was detected. For Fe element (ppm) 6. sample 7.62730> 5. sample 6.09664> 1. sample 5.98573> 7. sample 4.94376> 8. sample 4.00227> 3. sample 3.97268> 2. sample 2.86002> 9. sample 2.24437> 10. sample 2.14805> 4. sample 1.94488 was detected. For Ni element (ppm) 3. sample 4.03289> 2. sample 3.35966> 5. sample 3.03289> 10. sample 2.40776> 7. sample 2.25966> 8. sample 2.12725> 1. sample 2.09731> 9. sample 1.13725> 6. sample 0.57528> 4. sample 0.42975 was detected. For Zn element (ppm) 6. sample 5.60140> 7. sample 4.61005> 8. sample 3.11532> 9. sample 2.93509> 10. sample 1.61165> 1. sample 1.31459> 5. sample 1.14102> 2. sample 0.54353> 3. sample 0.46428> 4. sample 0.40256 was detected. For Sr element (ppm) 7. sample 2.75721> 3. sample 2.37148> 1. sample 1.74496> 4. sample 1.19448> 5. sample 1.17568> 9. sample 0.91081> 8. sample 0.56021> 10. sample 0.22849> 6. sample 0.16815> 2. sample 0.02110 was detected. For Ba element (ppm) 8. sample 1.14102> 6. sample 0.56021> 10. sample 0.54353> 7. sample 0.46428> 5. sample 0.45352> 1. sample 0.40813> 3. sample 0.15371> 9. sample 0.10781> 2. sample 0.01677> 4. sample 0.01638 was detected.

As shown in Table 2 the result of XRF analysis in sugar samples, first sugar sample elements (%) Na 0.40> Cl 0.368> Ca 0.059> K 0.029> Mg 0.015> Si 0.012 , Fe 0.012> Rh 0.008> Al 0.003> S 0.002. Second sugar sample elements (%) Na 0.174> Cl 0.132> Ca 0.053> K 0.016> Rh 0.016> Si 0.014 , Cu 0.014> Fe 0.013> Mg 0.012. Third sugar sample elements (%) Na 0.124> Cl 0.116> Ca 0.050> K 0.032> Rh 0.023> Si 0.014> Mg 0.010> Al 0.005. Fourth sugar sample elements (%) Ca 0.057> Na 0.055> Cl 0.051> Rh 0.029> Fe 0.018> Si 0.014> Mg 0.010> Al 0.005. Fifth sugar sample elements (%) Ca 0.019> Mg 0.014> Fe 0.011> S 0.005. Sixth sugar sample elements (%) Ca 0.055> Cl 0.040> Na 0.035> Rh 0.023> K 0.026> Si 0.014> Mg 0.008> Al 0.005> S 0.001. Seventh sugar sample elements (%) Ca 0.019> K 0.014> Si 0.010> Mg 0.009> Al 0.002. Ninth sugar sample elements (%) Ca 0.084> Na 0.035> Cl 0.030> Rh 0.023> Si 0.017 , Fe 0.017> Mg 0.014> K 0.012> Al 0.005> S 0.002 P 0.001. Tenth sugar sample elements (%) Ca 0.073> K 0.038> Na 0.026> Rh 0.025> Fe 0.024> Si 0.013> Mg 0.010> S 0.003 , Al 0.003.

As can be seen in Tables 1 and 2; ten chemical elements (Mg, Al, K, Ca, Mn, Fe, Ni, Zn, Sr and Ba) were detected by ICP-MS analytical method in sugar samples and fourteen chemical elements (Na, Cl, Ca, K, Mg, Si, Fe, Rh, Al, S, Cu, Zn, Zr and P) were detected by XRF analytical method.
The tables show that the elements (Na, Cl, Si, Rh, S, Cu, Zr, P) are not detected by ICP-MS method. On the other hand the elements (Mn, Ni, Sr, Ba) were not detected by XRF method.

Descriptive statistics test and normality test were performed using the IBM-SPSS-22 statistical program for the composites of table sugar (Table 3, 4). (SPSS for Windows &lt;/ RTI &gt; Inc., Version 22 Chicago, Illinois). The maximum, minimum and standard deviations of the elements found in the structure of the strands were found (Table 5, 6).
In our literature Sousa et al. (2010) determined inorganic species (Ca, Cd, Cu, Co, Fe, Mg, Mn, Na, Ni, Pb, Se and Zn) in solid sweeteners by ICP OES without employing a mineralization step. The analysis of different kinds of sweeteners showed different concentration profiles [6]. Leme et al. (2013) studied, analytical procedures for determination of inorganic constituents in honey samples from different regions of Brazil, inductively coupled plasma with mass spectrometry detection (ICP-MS) was used to determine the analytes [7]. Two multielemental analytical techniques, (XRF) and (ICP-AES) were used by Somogyi et al. (1997) for the analysis of the elemental composition of sediment samples. Good agreement was found for some elements, e.g. Mn, Zn and Sr, while the concentrations and the statistical conclusions were shown to depend on the analytical method used in the case of other elements, e.g. Fe and Zr [8]. Hilligoss et al. (1999) analyzed and compared seven different oils by using ICP-OES and XRF methods. Good agreement between ICP-OES and XRF analyses is evident [9]. Jarošova et al. (2014) determined the mineral nutrients and toxic elements in five types of coffee by atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry (ICP-MS).

No significant differences were found between the two used methods. Significant differences occurred between the coffee samples but only the application of multivariate statistics helps to distinguish among samples from different locations [10]. Our study is the first large-scale study in this field. It will be a guiding light for Industrial Sugar Production.

REFERENCES


