INTRODUCTION

Tea is one of the heavily consumed beverages in the Syria which is prepared from the leaf of a shrub camellia sinensis. It is also regarded as the most served beverage in the world. It is grown in acidic soil widely from tropical to temperate regions. Various kinds of tea including black, green and herbal, etc., are consuming at the high ratios. The chemical composition of tea leaves and manufactured tea are very complex and consists of tanning substances, flavones, alkaloids, proteins and amino acids, enzymes, aroma-forming substances, vitamins and 4-9 % inorganic matter.

The regular consumption of tea can contribute to the daily dietary requirements of traces of heavy metals including copper, iron, manganese, nickel and zinc in tea leaves. The optimization conditions involving the experiment factors: tea sample amount, microwave power and power time were studied for some kinds of tea consumed in Syria. The relative standard deviations of the method were found below 5 % for the 5 elements. The proposed method was used for the determination of the five elements in tea leaves consumed in Syria for 39 tea samples. The obtained concentration of copper, iron, manganese, nickel and zinc varied between 10.6-54.4, 74.8-854.9, 225.1-1633.1, 1.1-16.3 and 18.0-44.2 (µg/g), respectively.

EXPERIMENTAL

The present work describes tea leaf microwave digestion procedure by using new acid mixture (nitric acid and perchloric acid) for determining copper, iron, manganese, nickel and zinc in tea samples, employing flame atomic absorption spectrometry (FAAS). The optimization conditions involving the experiment factors: tea sample amount, microwave power and power time were studied for some kinds of tea consumed in Syria. The relative standard deviations of the method were found below 5 % for the 5 elements. The proposed method was used for the determination of the five elements in tea leaves consumed in Syria for 39 tea samples. The obtained concentration of copper, iron, manganese, nickel and zinc varied between 10.6-54.4, 74.8-854.9, 225.1-1633.1, 1.1-16.3 and 18.0-44.2 (µg/g), respectively. These metals were also determined in tea infusion in boiled distilled water during (2-30 min) for three different samples. The percentage of the element contents in the infusion related to the total amount in tea leave were: zinc 19.71-28.34 %, manganese 11.79-26.95 %, iron < 5 %, copper and nickel were below the detection limit.

Key Words: Microwave digestion, Manganese, Iron, Zinc, Copper, Nickel, Tea, Tea infusion, Flame atomic absorption spectrometry.
used for all dilutions. HNO₃ and HClO₄ were GR quality (Merck). All the plastic and glassware were cleaned by soaking in dilute HNO₃ and were rinsed with distilled water prior to use. The standard solutions used for calibration were produced by diluting a stock solution of 1000 mg/L of the given elements supplied by (Merck).

The calibration curves for analyte metals were drawn after setting various parameters of FAAS including wavelength, slit width, lamp current at an optimum level.

Tea samples were purchased from supermarkets in Aleppo city-Syria in the year 2010.

The microwave digestions were carried out in the experimental heating program for the digestion procedure which is given in Table-1.

After the optimization of the digestion conditions, about 1 g of an oven-dried tea sample was put in microwave tube with 6 mL of concentrated HNO₃ and 2 mL of concentrated HClO₄ and placed in 70 ºC water bath for 10 min, then it closed tightly and put in microwave to be digested by using heated program which is given in Table-1. The digested sample transferred to beaker and evaporated to about 5 mL, then transferred to volumetric flask 10 mL and completed to volume by distilled deionized water. A digested blank was carried out in the same way.

### RESULTS AND DISCUSSION

**Tea sample amount (TSA):** Metals concentration was studied in relation to tea sample amount by using acid mixture (HNO₃-HClO₄) and reference digestion program. The metals concentration in digested sample was constant until tea amount (1 g) (Table-2 and Fig. 1).

**Microwave power (MP):** Tea metals concentration was studied in relation to microwave power by using 1 g of tea leave. Expedience microwave power for a complete digestion was 600 watt. As it is given in Table-3 and Fig. 2.

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<tr>
<th>Step</th>
<th>Time (min)</th>
<th>Power (Watt)</th>
<th>Step</th>
<th>Time (min)</th>
<th>Power (Watt)</th>
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**TABLE-2**

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<th>RSD (%)</th>
<th>Cu</th>
<th>RSD (%)</th>
<th>Zn</th>
<th>RSD (%)</th>
<th>Fe</th>
<th>RSD (%)</th>
<th>Mn</th>
<th>RSD (%)</th>
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**TABLE-3**

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<th>Cu</th>
<th>RSD (%)</th>
<th>Zn</th>
<th>RSD (%)</th>
<th>Fe</th>
<th>RSD (%)</th>
<th>Mn</th>
<th>RSD (%)</th>
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</table>

N: Number of measurements for every sample.
Power time (PT): Tea metals concentration was studied in relation to power time by using 1 g of tea leave and microwave power 600 watt. The experience power time for a complete digestion was 8 min (Table-4 and Fig. 3).

![Effect of microwave power on tea leave metals concentration](image)

**TABLE-4**

<table>
<thead>
<tr>
<th>Power time (min)</th>
<th>Ni RSD (%)</th>
<th>Cu RSD (%)</th>
<th>Zn RSD (%)</th>
<th>Fe RSD (%)</th>
<th>Mn RSD (%)</th>
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<td>20.2</td>
<td>3.2</td>
<td>34.5</td>
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</table>

Elements concentration (µg/g) N: Number of measurements for every sample.

**TABLE-5**

<table>
<thead>
<tr>
<th>Element</th>
<th>Added (µg/g)</th>
<th>Found (µg/g)</th>
<th>Recovery (%)</th>
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<tr>
<td>Cu</td>
<td>40</td>
<td>59.20 ± 1.80</td>
<td>96.75</td>
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<td>Zn</td>
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<td>78.00 ± 1.20</td>
<td>95.83</td>
</tr>
<tr>
<td>Mn</td>
<td>80</td>
<td>97.80 ± 1.30</td>
<td>96.63</td>
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<tr>
<td>Ni</td>
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<td>15.78 ± 1.90</td>
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<tr>
<td>Cu</td>
<td>40</td>
<td>54.82 ± 0.67</td>
<td>97.60</td>
</tr>
<tr>
<td>Zn</td>
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<td>75.50 ± 0.63</td>
<td>99.53</td>
</tr>
<tr>
<td>Mn</td>
<td>80</td>
<td>95.55 ± 0.73</td>
<td>99.71</td>
</tr>
<tr>
<td>Fe</td>
<td>0</td>
<td>136.50 ± 1.67</td>
<td>-</td>
</tr>
<tr>
<td>Ni</td>
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<td>7.12 ± 4.40</td>
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</tr>
<tr>
<td>Zn</td>
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<td>9.10 ± 4.06</td>
<td>97.72</td>
</tr>
<tr>
<td>Mn</td>
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<td>486.46 ± 1.53</td>
<td>-</td>
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<td>Cu</td>
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<td>Mn</td>
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<td>1083.60 ± 1.25</td>
<td>99.52</td>
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</table>

N: Number of measurements for every sample.

**Conclusion**

The concentration of copper, iron, manganese, nickel and zinc in 39 various samples varied between 10.6-54.4, 74.8-854.9, 225.1-1633.1, 1.1-16.3 and 18.0-44.2 (µg/g), respectively. By comparison among the three countries of tea sources, it is observed that the Chinese tea leave content of each iron and manganese was the biggest. The amount of the elements contents in the metals infusion related to the total amount in leaves metals were: zinc 19.71-28.34 %, manganese 11.79-26.95 %, iron < 5 %, copper and nickel were below to the detection limit. It was observed that the biggest infused concentration of the zinc was at 10 and 8 min for the manganese. But the infused iron was negligible which assure its binding with the tea matrix.
### TABLE-6
CONCENTRATION OF COPPER, IRON, MANGANESE, NICKEL AND ZINC IN CHINESE TEA, CONSUMED IN SYRIA

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<th>Sample</th>
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<th>Fe</th>
<th>Mn</th>
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### TABLE-7
CONCENTRATION OF COPPER, IRON, MANGANESE, NICKEL AND ZINC IN CEYLON TEA, CONSUMED IN SYRIA

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<th>Sample</th>
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<th>Fe</th>
<th>Mn</th>
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### TABLE-8
CONCENTRATION OF COPPER, IRON, MANGANESE, NICKEL AND ZINC IN VIETNAMESE TEA, CONSUMED IN SYRIA

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<th>Sample</th>
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<th>Cu</th>
<th>Zn</th>
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<th>Mn</th>
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<td>17.20</td>
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Vol. 23, No. 7 (2011) Determination of Copper, Iron, Manganese, Nickel and Zinc in Tea Leaf 3271
TABLE 9
INFUSED PERCENTAGE OF IRON, MANGANESE AND ZINC TO DRINKING TEA THROUGH 2-30 min

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<th>Sample</th>
<th>Conc. (µg/g)</th>
<th>Conc. (µg/mL)</th>
<th>Transfer (%)</th>
<th>Conc. (µg/g)</th>
<th>Conc. (µg/mL)</th>
<th>Transfer (%)</th>
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