Evaluation of Lead, Cadmium and Copper Concentrations in Bee Honey and Edible Molasses

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Abstract: Problem statement: Content of Cadmium, lead and copper in 26 bee honey samples from different places of Assiut governorate (south of Egypt) and three different botanical origins (Clover, Multi-flower and Citrus) in addition to four edible molasses samples from Egypt market were evaluated by Differential Pulse Anodic Stripping Voltammetry (DPASV) in Briton-Robinson buffer solution at pH ~ 2.1, as well as atomic absorption spectrometry after wet digestion. Approach: The optimal deposition potentials and times for the detection of these metal ions in all sample solutions have been studied. Results: The concentration of each metal ion was determined by the standard addition method. The statistical parameters i.e., slope, standard deviation, correlation coefficient and confidence have been calculated. Conclusion/Recommendations: The results obtained using stripping voltammetry indicate that the average concentration of Cu ions ranged from 0.085-0.987 μg g⁻¹. In addition, the average concentrations of Cd and Pb ions ranged 0.001-0.077 and 0.006-1.640 μg g⁻¹; respectively. On the other hand, the average concentrations obtained using atomic absorption spectrometry of the same element mentioned above ranged from 0.077-0.991 μg g⁻¹ for Cu; 0.001-0.087 μg g⁻¹ for Cd and 0.007-1.650 μg g⁻¹ for Pb.

Key words: Stripping voltammetry, honey, molasses, biological indicator

INTRODUCTION

Honey is a quick, safe and natural energy giver because its simple sugar is quickly absorbed into the blood stream, honey is an easily digestible foodstuff containing a range of nutritionally important complementary elements. Besides a high content of a range of saccharides, there are also organic acids, amino acids, mineral matters, colors, aromatic substances and a trace amount of fats (Bogdanov et al., 1999). Besides these, honey contains very valuable but unstable compounds, such as enzymes, substance of hormonal character, some vitamins and a few minor compounds (Yilmaz and Yavuz, 1999). Honey contaminations by heavy metals (especially Pd, Cd and Cu) that are widely spread in our environment are the result of:

- The location of colonies in industrial zones or other areas with considerable air pollution such as cities, can lead to considerable contamination of various hive products with noxious or toxic chemicals. Agricultural use of toxic chemicals is another common and very likely source of contamination; further contamination may results from dirty water source and non-floral sugar source (Antonescu and Mateescu, 2001)
- The use of unpleasant smelling chemicals to drive bees away is a technique preferred by many beekeepers because it is quick and easy (Dadant and Sons, 1992)
- Containers previously used for toxic chemicals, oil or petroleum products or vessels doesn’t manufacture for food preservation should never be used for storing honey, because it is become a source of honey contamination by heavy metals

Several authors have indicated that bee and their products may be used as biological indicator (Fernandez et al., 1994; Sanna et al., 2000; Buldini et al., 2001; Bogdanov et al., 2003; Fredes and Montenegro, 2006). Copper is both vital and toxic for many biological system, it is critical for energy production in the cells, also involved in nerve conduction, connective tissue, the cardiovascular system and the immune system. Copper is closely related to estrogen metabolism and is required for women’s fertility and to maintain pregnancy. Copper stimulates production of the neurotransmitters epinephrine, norepinephrine and dopamine. It is also required for monoamine oxidase, an enzyme related to serotonin production. Also excess
copper may be absorbed in the intestinal tissues which lead to intestinal disorders, impaired healing and reduced resistance to infections (Wilson, 1998).

Cadmium is one of the few elements that have no constructive purpose in the human body. This elements and solution of its compound are extremely toxic even in low concentration and will bioaccumulation in organisms and ecosystems. One possible reason for its toxicity is that it interferes with the action of zinc-containing enzymes. Cadmium may also interfere with biological processes containing magnesium and calcium (Lide, 2005; Clarkson, 1988). Its toxicity threatens the health of the body by weakened immune system, kidney disease and live damage. Effects may include emphysema, cancer and a shortened life span (Lide, 2005).

Lead has no known biological role in the body. Its toxicity comes from its ability to mimic other biologically important metals, the most notable of which are calcium, iron and zinc. Lead is able to bind to and interact with the same proteins and molecules as these metals, but after displacement, those molecules function differently and fail to carry out the same reactions, such as in producing enzymes necessary for certain biological processes. Most lead poisoning symptoms are thought to occur by interfering with an essential enzyme Delta-aminolevulenic acid dehydratase, or ALAD (a zinc-binding protein which is important in the biosynthesis of heme, the cofactor found in hemoglobin) (Simon and Hudes, 1999). It inhibits several enzymes critical to the synthesis of heme, causing a decrease in blood hemoglobin and interferes with a hormonal form of vitamin D, which affects multiple processes in the body, including cell maturation and skeletal growth. Lead can also cause hypertension, reproductive toxicity and developmental effects. Lead exposure can lead to renal effects such as Fanconi-like syndromes, chronic nephropathy and gout (Batuman et al., 1981).

Recently, several methods of analysis were done for determination of cadmium, lead and copper, e.g., by stripping voltammetry (Sanna et al., 2000; Buldini et al., 2001; Li et al., 1995), potentiometric stripping analysis (Munoz and Palmero, 2006), atomic absorption spectroscopy (Bogdanov et al., 1999; Antonescu and Mateescu, 2001; Vinas et al., 1997; Rodriguez-Garcia et al., 2003; Taddia et al., 2004; Tuzen and Soylak, 2005; Ajtony et al., 2007), inductively coupled plasma atomic emission spectrometry (Caroli et al., 1999; Ioannidou et al., 2005; Terrab et al., 2005). Inductively coupled plasma mass spectrometry (Packer and Gine, 2001), inductively coupled plasma optical emission spectrometry (Fredes and Montenegro, 2006; Lachman et al., 2007), total reflection X-ray fluorescence spectrometry (Kump et al., 1996).

MATERIALS AND METHODS

Apparatus: All glassware was soaked in 10% (v/v) HNO₃ for 24 h and rinsed three times with distilled water and then in redistilled water before use:

- Polarographic analyzer/striping voltameter. Anodic differential pulse stripping voltammograms were recorded with an EG and G. Princeton Applied Research Crop. (PAR; Princeton, NJ) model 264 A stripping analyzer, coupled with a PAR 303 A Hanging Mercury Drop Electrode (HMDE). The polarographic cell (PAR Model K0060) was fitted with Ag/AgCl saturated KCl and used as a reference electrode with a platinum wire as a counter (auxiliary) electrode. A PAR 305 magnetic stirrer was connected to the 303A SMDE. A PAR Model RE 0151X-Y recorder was used to collect experimental data. Before measurements the sample solution was deaerated by bubbling for 16 minutes with nitrogen. During measurements, an inert atmosphere over the solution was maintained by flushing with nitrogen. During the deposition step, the solution was stirred automatically, followed by a quiescent period of 15 sec before scanning.

- PH was measured with a Fischer Scientific (Pittsburgh, PA, USA) digital pH Meter Model 810

- GBC 906 atomic absorption spectrophotometer was used for Cu(II) measurement at Wavelength 324.7 nm, band-pass 0.7 nm and lamp current 6.0 mA and a AA-6800 Shimadzu (GFA-EX7) Graphite Furnace atomic absorption spectrophotometer was used for Cd(II) and Pb(II) determination at band-pass 0.7 nm, lamp current 8.0 mA and Wavelength 228.9 and 283.2 nm respectively.

Solution and reagents: All reagents are of analytical grade. The following solutions were prepared with bidistilled water:

- Solution of each Cd(II), Pb(II) and Cu(II) were prepared respectively by dissolving the required amounts of Cd(NO₃)₂.4H₂O, Pb(NO₃)₂ and Cu(NO₃)₂.2H₂O in bidistilled water. The resulting solutions were then standardized (Vogel and Basset, 1978). Solutions of lower concentrations were prepared by accurate dilution.
**Table 1**: The sources and cadmium content of different clover (BC), multi-flower (MC) and citrus (OC) honey samples and edible molasses samples (EM) (a mean value ± standard deviation for \( n = 5 \) at the 95% confidence level)

| Samples number | Geog. sources | \( T_a \) (sec) | Cadmium content (mean ± SD) \( \mu g g^{-1} \) | Correction coefficient | Confidence | Cadmium content (mean ± SD) \( \mu g g^{-1} \) (GFAAS) |
|----------------|---------------|-----------------|---------------------------------------------|------------------------|------------|---------------------------------------------|
| BC\(_1\)       | Assiut        | 120             | 0.027±0.00600                                | 0.9998                 | 0.0350    | 0.0190                                       |
| BC\(_2\)       | Sedfa         | 45              | 0.055±0.00300                                | 0.9996                 | 0.0590    | 0.0510                                       |
| BC\(_3\)       | Abutig        | 90              | 0.042±0.00500                                | 0.9993                 | 0.0480    | 0.0360                                       |
| BC\(_4\)       | Dairut        | 90              | 0.052±0.00300                                | 0.9995                 | 0.0560    | 0.0520                                       |
| BC\(_5\)       | Al-Qusiya     | 120             | 0.029±0.00200                                | 0.9999                 | 0.0320    | 0.0270                                       |
| BC\(_6\)       | Manfalut      | 120             | 0.042±0.00600                                | 0.9998                 | 0.0490    | 0.0350                                       |
| BC\(_7\)       | Al-Ghanayem   | 60              | 0.013±0.00100                                | 0.9998                 | 0.0140    | 0.0120                                       |
| BC\(_8\)       | Abnub         | 120             | 0.024±0.00100                                | 0.9999                 | 0.0250    | 0.0230                                       |
| BC\(_9\)       | Sahil Salem   | 90              | 0.047±0.00200                                | 0.9995                 | 0.0490    | 0.0450                                       |
| MC\(_1\)       | Assiut        | 120             | 0.025±0.00200                                | 0.9996                 | 0.0320    | 0.0260                                       |
| MC\(_2\)       | Sedfa         | 120             | 0.023±0.00100                                | 0.9999                 | 0.0330    | 0.0300                                       |
| MC\(_3\)       | Abutig        | 45              | 0.033±0.00100                                | 0.9999                 | 0.0340    | 0.0320                                       |
| MC\(_4\)       | Dairut        | 120             | 0.051±0.00200                                | 0.9993                 | 0.0530    | 0.0480                                       |
| MC\(_5\)       | Al-Qusiya     | 120             | 0.043±0.00200                                | 0.9992                 | 0.0460    | 0.0410                                       |
| MC\(_6\)       | Manfalut      | 120             | 0.077±0.00400                                | 0.9997                 | 0.0820    | 0.0720                                       |
| MC\(_7\)       | Al-Ghanayem   | 30              | 0.0044±0.0001                                | 1.0000                 | 0.0045    | 0.0043                                       |
| MC\(_8\)       | Abnub         | 60              | 0.0067±0.0003                                | 0.9992                 | 0.0070    | 0.0063                                       |
| MC\(_9\)       | Sahil Salem   | 120             | 0.014±0.00100                                | 0.9993                 | 0.0150    | 0.0130                                       |
| MC\(_10\)      | Al-Badary     | 60              | 0.016±0.00200                                | 0.9997                 | 0.0190    | 0.0140                                       |
| MC\(_11\)      | Al-Fateh      | 60              | 0.008±0.00100                                | 0.9996                 | 0.0090    | 0.0070                                       |
| MC\(_12\)      | Mangapad      | 120             | 0.067±0.00300                                | 0.9991                 | 0.0710    | 0.0630                                       |
| OC\(_1\)       | Sahil Salem   | 120             | 0.048±0.00300                                | 0.9997                 | 0.0520    | 0.0440                                       |
| OC\(_2\)       | Al-Badary     | 30              | 0.055±0.00600                                | 0.9998                 | 0.0630    | 0.0480                                       |
| EM\(_1\)       | Al-Hana       | 60              | 0.066±0.00700                                | 0.9995                 | 0.0750    | 0.0570                                       |
| EM\(_2\)       | El-Seid, Mallawi, | 120          | 0.001±0.000100                              | 0.9992                 | 0.0011    | 0.0009                                       |
| EM\(_3\)       | El-Kother     | 90              | 0.061±0.00200                                | 0.9994                 | 0.0640    | 0.0590                                       |
| EM\(_4\)       | Al-Temsah     | 120             | 0.010±0.00100                                | 0.9995                 | 0.0110    | 0.0090                                       |

- Briton-Robinson buffer solution was prepared by dissolving 201 \( \mu L \) glacial acetic acid (AnalaR), 240 \( \mu L \) phosphoric acid (Merck) and 433 mg boric acid (BDH) in 500 ml measuring flask with bidistilled water (Ensafi et al., 2004).

**Honey samples**: Twenty-six bee honey samples were collected from Assiut governorate (south of Egypt) and four edible molasses as shown in Table 1. Samples were collected in glass bottles and stored in dark prior to analysis.

**Sample preparation**: One gram of sample was treated with 10 mL of concentrated nitric acid, in a beaker, heating until nearly dry. This procedure was repeated with 15 mL of a 2:1 (\( HNO_3/HClO_4 \)) mixture until complete mineralization. The residue was dissolved, at room temperature, in 1ml of 1M nitric acid, transferred to a 100 mL volumetric flask and diluted with bidistilled water (Fernandez-Torres et al., 2005). A control reagent blank was prepared in the same manner to determine the ultra trace impurities using the standard addition method as already used for the sample.

**Analytical procedure**: The following parameters were used to perform Differential Pulse Anodic Stripping Voltammetry (DPASV). Scan rate 10 mV\( s^{-1} \) with duration for 1 sec and pulse amplitude (\( \Delta E \)) 25 mV. For determination of Cd(II), Pb(II) and Cu(II) in bee honey and edible molasses samples in the same cell. 5 mL of each sample solution and 1 mL of 0.028 M Briton-Robinson buffer solution as supporting electrolyte were transferred into the electrolysis cell and completed to 10 mL using bidistilled water (pH ~ 2.1).
The solution was deaerated by passing pure nitrogen for 16 min. The deposition potential were controlled at (-0.75, -0.55 and -0.25 V Vs Ag/AgCl saturated KCl respectively) and applied to a fresh mercury drop while the solution was stirred. After the deposition step and further 15 sec. (equilibrium time) the voltammogram was recorded.

Different concentration from the standard metal ion (individually) were added to the cell using an automatic pipette (Volac 10-100 μL), while keeping the deposition time constant. The solution was stirred and purged with nitrogen for 30 sec. after each spike. The concentration of each Cd(II), Pb(II) and Cu(II) in the electrolytic cell was calculated in the sample solutions by using standard addition method, Then the concentration in μg g⁻¹ of each bee honey and edible molasses samples were calculated.

RESULTS AND DISCUSSION

In order to set the optimal condition of the three cations, preliminary measurements were made to obtain the highest peak signal for metal ions Cd(II), Pb(II) and Cu(II) in solution samples. It was noticed that, Briton-Robinson buffer solution (pH ~ 2.1) gave promising results for the determination of Cd, Pb and Cu ions.

The effect of deposition potential of each metal ion was studied and it was observed that the highest and best shape peaks for Cd²⁺, Pb²⁺ and Cu²⁺ were at deposition potentials -0.75, -0.55 and -0.25 V Vs. Ag/AgCl/ KCl sat. respectively.

The effect of deposition time on the oxidation peak signals of these metal ions was examined. Figure 1 shown differential pulse anodic stripping voltammograms of Pb(II) in BC₃ in buffer solution at different deposition times. The optimal deposition times were selected for these metal ions of all sample solutions in a manner that linear relation must be established between deposition times and current signals and listed in Table 1-3.

DPAS voltammetric determination of Cd(II): Figure 2 represents the differential pulse anodic stripping voltammograms of BC₃ sample solution in absence and in presence of the addition of standard cadmium ions in Briton-Robinson buffer solution of pH ~ 2.1. On plotting of peak current against concentrations for twelve clover honey sample solutions (BC x) in the same supporting electrolyte at the same conditions, straight lines are obtained (standard addition method) as shown in Fig. 3.

![Fig. 1: DPAS Voltammograms of Pb(II) in BC₂ sample in presence of 0.028 M Briton-Robinson buffer solution, pH ~ 2.1 at deposition potential -0.55 V and different deposition times. (a) zero; (b) 10; (c) 20; (d) 30; (e) 40; (f) 50; (g) 60 sec](image1)

![Fig. 2: DPAS Voltammograms of Cd(II) in BC₃ sample spiked with different concentrations of Cd(II) ions in 0.028 M Briton-Robinson buffer solution, pH ~ 2.1 at deposition potential -0.75 V and deposition time 90 sec, (a) sample, S; (b) S+3×10⁻⁹; (c) S+6×10⁻⁹; (d) S+9×10⁻⁹; (e) S+12×10⁻⁹; (f) S+15×10⁻⁹; (g) S+18×10⁻⁹ M Cd(II)](image2)
Fig. 3: Standard addition plots of Cd(II) in BCx samples: (1) BC1 at 120 sec; (2) BC2 at 45 sec; (3) BC3 at 90 sec; (4) BC4 at 90 sec; (5) BC5 at 120 sec; (6) BC6 at 120 sec; (7) BC7 at 60 sec; (8) BC8 at 120 sec; (9) BC9 at 120 sec; (10) BC10 at 90 sec; (11) BC11 at 30 sec; (12): BC12 at 120 sec at deposition potential -0.75 V using DPASV

Fig. 4: Standard addition plots of Pb(II) in MCx Samples: (1) MC1 at 10 sec; (2): MC2 at 30 sec; (3) MC3 at 10 sec; (4) MC4 at 30 sec; (5) MC5 at 60 sec; (6) MC6 at 30 sec; (7) MC7 at 45 sec; (8) MC8 at 10 sec; (9) MC9 at 45 sec; (10): MC10 at 15 sec; (11) MC11 at 15 sec; (12): MC12 at 20 sec at deposition potential -0.55 V using DPASV

From the interceptions of these lines with the concentration axis at zero current signals, one can calculate the concentration of Cd(II) in each sample. The concentration of Cd(II) ions in all samples (bee honey and edible molasses) under consideration using DPASV are listed in Table 1. The results indicate that, the concentrations of Cd(II) are ranged from 0.001-0.077 μg g⁻¹.

DPAS voltammetric determination of Pb(II):

Figure 4 shows the standard addition plots of i.p. against Pb(II) concentration for twelve multi-flower honey sample solutions (MCx) in Briton-Robinson buffer solution of pH ~ 2.1 at deposition potential -0.55 volt. From the interceptions of these straight lines with the concentration axis at zero current signal, the concentration of Pb(II) ions in all samples (bee honey and edible molasses) under consideration using DPASV was calculated and the resulting concentration values are listed in Table 2. The results indicate that, the concentration of Pb(II) ions are ranged from 0.006-1.640 μg g⁻¹.

DPAS voltammetric determination of Cu(II):

Figure 5 shows the standard addition plots of i.p against Cu(II) concentration for four edible molasses sample solutions (EMx) in Briton-Robinson buffer solution of pH ~ 2.1 at deposition potential -0.25 volt. From the interceptions of these straight lines with the concentration axis at zero current signal gives the concentration of Cu(II) in the voltammetric cell for each sample. After correction for the background current of blank experiments. The concentration of Cu(II) ions in all samples (bee honey and edible molasses) under consideration using DPASV are shown in Table 3. It was found that, the mean levels of Cu(II) ions are ranged from 0.085-0.987 μg g⁻¹.

The precision and reproducibility of the selected procedure were investigated by measuring the concentration of Cd(II), Pb(II) and Cu(II) in all bee honey and edible molasses samples under consideration for (n = 5).
Table 2: Lead content of different clover (BCx), multi-flower (MCx) citrus (OCx) honey samples and edible molasses samples (EMx) (a mean value ± standard deviation for n = 5 at the 95% confidence level)

| Samples number | Lead content (mean ± SD) μg g⁻¹ | Correction coefficient | Confidence interval | Cadmium content (mean ± SD) μg g⁻¹ (GFAAS) |
|----------------|----------------------------------|------------------------|-------------------|--------------------------------------------|
| BC1            | 1.640±0.081                      | 0.9995                 | 1.741             | 1.539                                      |
| BC2            | 0.616±0.021                      | 0.9993                 | 0.642             | 0.589                                      |
| BC3            | 1.060±0.062                      | 0.9966                 | 1.138             | 0.984                                      |
| BC4            | 0.595±0.043                      | 0.9995                 | 0.645             | 0.545                                      |
| BC5            | 0.124±0.011                      | 1.0000                 | 0.138             | 0.110                                      |
| BC6            | 0.093±0.009                      | 1.0000                 | 0.104             | 0.082                                      |
| BC7            | 1.521±0.042                      | 0.9992                 | 1.573             | 1.469                                      |
| BC8            | 0.263±0.032                      | 0.9990                 | 0.303             | 0.223                                      |
| BC9            | 0.507±0.022                      | 0.9990                 | 0.521             | 0.493                                      |
| BC10           | 0.261±0.022                      | 0.9999                 | 0.287             | 0.233                                      |
| MC1            | 0.130±0.011                      | 0.9993                 | 0.143             | 0.117                                      |
| MC2            | 1.610±0.121                      | 0.9994                 | 1.762             | 1.462                                      |
| MC3            | 0.702±0.081                      | 0.9992                 | 0.802             | 0.601                                      |
| MC4            | 0.178±0.006                      | 0.9998                 | 0.186             | 0.171                                      |
| MC5            | 0.087±0.003                      | 0.9993                 | 0.091             | 0.083                                      |
| MC6            | 0.404±0.022                      | 0.9993                 | 0.431             | 0.377                                      |
| MC7            | 0.200±0.013                      | 0.9993                 | 0.216             | 0.184                                      |
| MC8            | 0.438±0.081                      | 0.9992                 | 0.539             | 0.337                                      |
| MC9            | 0.806±0.054                      | 0.9993                 | 0.873             | 0.739                                      |
| MC10           | 1.065±0.104                      | 0.9992                 | 1.194             | 0.936                                      |
| OC1            | 0.101±0.011                      | 0.9992                 | 0.115             | 0.087                                      |
| OC2            | 0.324±0.021                      | 0.9995                 | 0.351             | 0.298                                      |
| EM1            | 0.006±0.001                      | 0.9994                 | 0.007             | 0.005                                      |
| EM2            | 0.051±0.004                      | 0.9994                 | 0.056             | 0.046                                      |
| EM3            | 0.138±0.005                      | 0.9994                 | 0.144             | 0.132                                      |
| EM4            | 0.201±0.011                      | 0.9991                 | 0.215             | 0.187                                      |

The values of slopes, intercepts, confidence intervals, standard deviations and correlation coefficient obtained for all samples are listed in Table 1-3. These statistical parameter values indicate the reproducibility of the procedure for determination of each Cd(II), Pb(II) and Cu(II) in all samples in this Briton-Robinson buffer solution, PH ~ 2.1.

Flame atomic absorption spectrometric determination of copper: Copper was determined by atomic absorption spectroscopy of the treated sample solutions at 324.7 nm. The concentration values of each sample are listed in Table 3. It was found that the concentration of copper is ranged between 0.077-0.991 μg g⁻¹. From Table 3 it was found that, the data obtained by stripping voltammetry are in a close agreement with those obtained by flame atomic absorption spectrometry. Flame atomic absorption spectrometric method was not obeyed for determination of cadmium and lead, so the concentration of each cadmium and lead is less than the detection limits of the FAAS technique.

Graphite furnace atomic absorption spectrometric determination of cadmium and lead: Cadmium and lead were determined by graphite furnace atomic absorption spectrometry at 228.9 and 283.2 nm respectively. The resulting data of cadmium and lead were listed in Table 1 and 2 respectively. From Table 1 and 2, it was found that, the resulting data obtained by stripping voltammetry are in a close agreement with those obtained by graphite furnace atomic absorption spectrometry.

The foregoing results indicated that, copper, cadmium and lead contents in the bee honey and edible molasses samples are less than that permissible values which given by WHO and FAO and differ from each other’s according to its botanical sources (only in case of bee honey), environment contamination, production and storage.
Table 3: Copper content of different clover (BC\textsubscript{x}), multi-flower (MC\textsubscript{x}) and citrus (OC\textsubscript{x}) honey samples and edible molasses samples (EM\textsubscript{x}) (a mean value ± standard deviation for n = 5 at the 95% confidence level)

| Regression parameter | Copper content (mean ± SD) μg g\textsuperscript{-1} | Confidence coefficient | Cadmium content (mean ± SD) μg g\textsuperscript{-1} (GFAAS) |
|---------------------|--------------------------------|----------------------|-------------------------------------------------|
| Samples number      | T\textsubscript{d} (sec) |                        | Higher Lower                                    |
| BC\textsubscript{1}  | 40                     | 0.497±0.052           | 0.559 0.435                                    | 0.503±0.011 |
| BC\textsubscript{2}  | 30                     | 0.230±0.013           | 0.242 0.218                                    | 0.238±0.021 |
| BC\textsubscript{3}  | 45                     | 0.242±0.021           | 0.267 0.217                                    | 0.252±0.009 |
| BC\textsubscript{4}  | 30                     | 0.696±0.091           | 0.809 0.583                                    | 0.701±0.042 |
| BC\textsubscript{5}  | 45                     | 0.300±0.012           | 0.315 0.285                                    | 0.292±0.024 |
| BC\textsubscript{6}  | 45                     | 0.193±0.009           | 0.204 0.182                                    | 0.189±0.018 |
| BC\textsubscript{7}  | 30                     | 0.220±0.023           | 0.248 0.191                                    | 0.225±0.012 |
| BC\textsubscript{8}  | 30                     | 0.987±0.121           | 1.137 0.837                                    | 0.991±0.051 |
| BC\textsubscript{9}  | 45                     | 0.255±0.023           | 0.284 0.226                                    | 0.251±0.022 |
| BC\textsubscript{10} | 10                     | 0.085±0.012           | 0.099 0.071                                    | 0.077±0.004 |
| BC\textsubscript{11} | 15                     | 0.165±0.013           | 0.181 0.149                                    | 0.177±0.021 |
| BC\textsubscript{12} | 15                     | 0.813±0.093           | 0.821 0.677                                    | 0.828±0.061 |
| MC\textsubscript{1}  | 30                     | 0.398±0.041           | 0.449 0.347                                    | 0.407±0.015 |
| MC\textsubscript{2}  | 10                     | 0.555±0.014           | 0.572 0.538                                    | 0.552±0.023 |
| MC\textsubscript{3}  | 30                     | 0.512±0.082           | 0.614 0.411                                    | 0.525±0.051 |
| MC\textsubscript{4}  | 45                     | 0.161±0.013           | 0.177 0.145                                    | 0.158±0.011 |
| MC\textsubscript{5}  | 20                     | 0.335±0.021           | 0.361 0.309                                    | 0.335±0.043 |
| MC\textsubscript{6}  | 30                     | 0.303±0.013           | 0.319 0.287                                    | 0.300±0.017 |
| MC\textsubscript{7}  | 30                     | 0.393±0.032           | 0.433 0.353                                    | 0.401±0.009 |
| MC\textsubscript{8}  | 45                     | 0.275±0.013           | 0.291 0.259                                    | 0.292±0.013 |
| MC\textsubscript{9}  | 45                     | 0.646±0.033           | 0.687 0.605                                    | 0.656±0.021 |
| MC\textsubscript{10}| 15                     | 0.309±0.011           | 0.323 0.295                                    | 0.323±0.012 |
| MC\textsubscript{11}| 30                     | 0.301±0.013           | 0.317 0.285                                    | 0.298±0.012 |
| EM\textsubscript{1}  | 15                     | 0.315±0.009           | 0.326 0.304                                    | 0.322±0.016 |

CONCLUSION

The use of Briton-Robinson buffer solution after a wet digestion method for determination of Cd(II), Pb(II) and Cu(II) ions by differential pulse anodic stripping voltammetry is selected method for determination of these metal ions in bee honey and edible molasses samples. This procedure presented a better detection limit than others, which reported in the literature. This method is also allowed Cd, Pb and Cu determination in the same voltammetric cell without external addition of base to change the pH value. The time of determination is shorter than that by other methods. From the foregoing results, one can concluded that, the application of standard addition method for anodic stripping voltammetric determination of divalent cadmium, lead and copper in honey samples as well as in edible molasses samples is suitable and successful.

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