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Determination of Mineral Contents in Dehydrated Egg Powder by ICP-OES

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Quantitative analyses were conducted on four different dehydrated egg powders. The essential elements *i.e.*, phosphorous, calcium, iron, magnesium, potassium, sodium and zinc, essential trace elements (selenium, copper, chromium, manganese) and potentially toxic, elements (arsenic, cadmium, lead, mercury) were determined by ICP-OES. The method was optimized and evaluated with the use of certified reference material. Inorder to evaluate the mineral content in the egg powders, microwave digestion was used to digest the sample. The results in the whole egg powder (mg kg^{-1}) were: As 0.163, Se 102.6 ± 1.0, Zn 36.35, P 804.5 ± 2.0, Pb 1.131, Fe 123.8 ± 5.0, Mg 458.9 ± 5.0, Ca 1123 ± 2, Na 241.2 ± 1 and K 439 ± 3. It was concluded that, for most essential elements, dehydrated egg powder contribute to mineral nutrition and play a key role in the human nutrition's.

Keywords: Micronutrient elements, Heavy metals.

INTRODUCTION

Eggs and egg powders are widely used as ingredients in the food industry because of their nutritional, functional and sensory qualities. Nutritionally, eggs are particularly interesting because they contain high-quality proteins, lipids, vitamins and minerals[1].

Recently, there has been an increased demand for dried egg products in the food industry for ready-to-use products and handling considerations. Recently, the use of shell egg in food production, as the raw material has reduced with the technological developments around the world food industry and egg products such as frozen egg, pasteurized liquid egg and dried egg products have gained popularity[2]. Oven drying is one of the techniques frequently used to obtain powdered eggs from liquid eggs[3]. There have been some problems with the estimation of the micro mineral composition in eggs. The used methodologies had been either time consuming and costly, or importantly did not allow simultaneous estimation of the micro minerals concerned. Inductively coupled plasma mass spectrometry (ICP-OES) is well established as a method for multi elemental analysis and the determination of isotope ratios[4] and overcomes many of these problems. This methodology allows simultaneous analysis of a wide range of trace elements in the same sample and has been used in this study.

The objective of the present study was the analysis of trace element (As, Hg, Se, Zn, P, Pb, Cd, Fe, Mn, Cr, Mg, Cu, Ca, Na and K) levels in the dehydrated powder of egg white, egg yolk, egg shell and whole egg powder using inductively coupled plasma optical emission spectrometry (ICP-OES).

EXPERIMENTAL

The analysis of minerals in egg shell powder, egg yolk powder, egg white powder and whole egg powder samples were determined by ICP-OES method[5]. All minerals and heavy metals measurements were carried out using the Perkin-Elmer Optima ICP- OES (Model: OPTIMA2000DV, Seial number: 080N3041701) and the ICP-OES operating conditions are listed in Table-1.

Reagents and chemicals: Analytical reagents-grade chemicals were used in the preparation of all solutions. All the plastic and glassware were cleaned by soaking in dilute nitric acid (1 + 9) and were rinsed with distilled water prior to use. Nitric acid (65 %), hydrogen peroxide (30 %) were supplied by Merck (India)

Sample preparation: The samples were digested using microwave digestion method (Model: ETHOS One, Make - Millestone). The samples of approximately 1 g was digested with 6 mL of HNO_3 and 2 mL of H_2O_2 in microwave digestion system. The sample and acid are placed in suitably inert polymeric microwave vessels. The vessel is sealed and heated in the microwave digestion system. The temperature program was as follows: 2 min for 400 w, 2 min for 400 w, 6 min for 400 w, 5 min for 400 w, 8 min for 800 w and 8 min for vent. The resulting solutions were cooled and diluted to 10 mL with distilled water. Determination of metal contents in this solution

TABLE-1
INSTRUMENTAL CONDITIONS AND PARAMETERS PARAMETER SETTING

Nebulizer	Bergener PEEK MiraMist
Spray chamber	Cyclonic
RF power	1300 W
Sample injector	2.0 mm i.d. alumina
Nebulizer argon flow	0.80 L/min
Sample uptake rate	1.80 mL/min
Auto integration	5-20 sec (Min-Max)
Data processing mode	Peak Area
Read delay	60 sec
Rinse delay	20 sec
Replicates	3

was carried out by inductively coupled plasma-optical emission spectrometry (ICP-OES).

Inductively coupled plasma-optical emission spectrometry (ICP-OES) analysis of samples: All samples were analyzed in triplicates by ICP-OES Perkin-Elmer; model Optima™ 2000 DV, using WinLab32 software for the analysis. The analytical measurements were made with a simultaneous Perkin-Elmer ICP OES, model Optima 2000DV, WinLab32™, Version 7.0 software equipped with a peristaltic pump, a cross-flow nebulizer (coupled to a Ryton double pass spray chamber) and a ceramic central torch tube injector with an internal diameter of 2 mm. The operating parameters are listed in Table-1. The wavelengths, measurement parameters and standards for each element are given in Table-2.

Analysis of certified reference material (CRM) of minerals and calibration: Aliquots of an ICP multi-element standard solution (10 to 50 mg/L Merck) containing the analyzed elements (As, Hg, Se, Zn, P, Pb, Cd, Fe, Mn, Cr, Mg, Cu, Ca, Na and K) were used in the preparation of calibration solutions. Working standard solutions were prepared by dilution of the stock standard solutions to desired concentration in 1 % HNO_3. The ranges of the calibration curves (5 points) were selected to match the expected concentrations for all the elements of the sample studied by ICP-OES. The correlation coefficient r^2 obtained for all cases was 0.9999 and the calibration summary was given in Table-3.

RESULTS AND DISCUSSION

The elements such as arsenic, mercury, selenium, zinc, phosphorous, lead, cadmium, iron, manganese, chromium, magnesium, copper, calcium, sodium, potassium were analyzed and results were given in Table-4. The result shows that calcium was determined highest (1456 ± 5 mg/kg) in egg shell powder, egg yolk (1293 ± 3 mg/kg) and whole egg powder (1123 ± 2 mg/kg), followed by phosphorous was 935.7 ± 1 mg/kg in

TABLE-2
WAVELENGTHS, MEASUREMENT PARAMETERS AND STANDARDS FOR EACH ELEMENT

Element	Wave length (nm)	Plasma (L/min)	Aux (L/min)	Neb (L/min)	Power	View mode	Calibration (mg/Kg)
Arsenic (As)	188.979	15	0.2	0.8	1300	Axial	10 - 50
Mercury (Hg)	194.168	15	0.2	0.8	1300	Axial	10 - 50
Selenium (Se)	196.026	15	0.2	0.8	1300	Axial	10 - 50
Zinc (Zn)	206.200	15	0.2	0.8	1300	Axial	10 - 50
Phosphorous (P)	213.617	15	0.2	0.8	1300	Radial	10 - 50
Lead (pb)	220.353	15	0.2	0.8	1300	Axial	10 - 50
Cadmium (Cd)	228.802	15	0.2	0.8	1300	Axial	10 - 50
Iron (Fe)	238.204	15	0.2	0.8	1300	Radial	10 - 50
Manganese (Mn)	257.610	15	0.2	0.8	1300	Radial	10 - 50
Chromium (Cr)	267.716	15	0.2	0.8	1300	Axial	10 - 50
Magnesium (Mg)	280.271	15	0.2	0.8	1300	Radial	10 - 50
Copper (Cu)	327.393	15	0.2	0.8	1300	Axial	10 - 50
Calcium (Ca)	393.366	15	0.2	0.8	1300	Radial	10 - 50
Sodium (Na)	589.592	15	0.2	0.8	1300	Radial	10 - 50
Potassium (K)	766.490	15	0.2	0.8	1300	Radial	10 - 50

TABLE-3
CALIBRATION SUMMARY

Element	Wave length (nm)	Standards	Equation	Intercept	Slope	Corr. coef.
Arsenic (As)	188.979	5	Linear	475281.3	5062000	0.997165
Mercury (Hg)	194.168	5	Linear	2049.4	2990	0.979180
Selenium (Se)	196.026	5	Linear	7839.3	34490	0.994588
Zinc (Zn)	206.200	5	Linear	1473.3	4980	984151
Phosphorous (P)	213.617	5	Linear	45468.8	396600	0.998505
Lead (pb)	220.353	5	Linear	817.0	4268	0.995374
Cadmium (Cd)	228.802	5	Linear	25473.2	79680	0.994841
Iron (Fe)	238.204	5	Linear	19969.6	88350	0.992947
Manganese (Mn)	257.610	5	Linear	211727.9	976300	0.994079
Chromium (Cr)	267.716	5	Linear	30480.3	123500	0.991826
Magnesium (Mg)	280.271	5	Linear	141452.8	549200	0.997079
Copper (Cu)	327.393	5	Linear	70582.2	355800	0.997707
Calcium (Ca)	393.366	5	Linear	27737.3	96280	0.988638
Sodium (Na)	589.592	5	Linear	211187.8	3661000	0.996874
Potassium (K)	766.490	5	Linear	28314.6	1442000	0.996083

TABLE-4
MINERAL CONTENT ESTIMATION IN DEHYDRATED EGG POWDER BY ICP-OES

Element with wavelength	Wave length (nm)	Results mg/kg of egg powder (dry basis)				Detection limit (ppb)
		Egg white powder	Egg shell powder	Egg Yolk powder	Whole egg powder	
Arsenic (As)	188.979	0.081	0.019	0.194	0.163	1-10
Mercury (Hg)	194.168	*BDL	*BDL	*BDL	*BDL	1-10
Selenium (Se)	196.026	131.65± 3.0	38.6	81.65	102.6± 3.0	1-10
Zinc (Zn)	206.200	0.358	BDL	34.19	36.35	0.1-1
Phosphorous (P)	213.617	94.5	41.5	935.7± 1.0	804.5± 2.0	1-10
Lead (pb)	220.353	0.443	0.0167	0.853	1.131	1-10
Cadmium (Cd)	228.802	BDL	BDL	BDL	BDL	<0.1
Iron (Fe)	238.204	0.165	BDL	44.14	123.8 ± 5.0	<0.1
Manganese (Mn)	257.610	0.11	BDL	5.703	2.013	0.1-1
Chromium (Cr)	267.716	0.051	0.058	4.662	1.073	0.1-1
Magnesium (Mg)	280.271	78.09	17.29	353.2	458.9± 5.0	<0.1
Copper (Cu)	327.393	0.175	BDL	0.191	0.537	0.1-1
Calcium (Ca)	393.366	106.4	1456± 5.0	1293± 3.0	1123± 2.0	<0.1
Sodium (Na)	589.592	462.4± 3.0	43.7	135.6	241.2± 1.0	0.1-1
Potassium (K)	766.490	610.3± 1.0	127.1	548.3± 2.0	439 ± 3.0	0.1-1

*BDL-Below detection limit

egg yolk powder and whole egg powder (804.5 ± 2 mg/kg). Calcium is essential for healthy bone growth and for nerve and muscle functions. It may protect against high blood pressure[6]. Chicken eggs are increasingly recognized as an important source of nutrients, including micro minerals. The potassium in egg white powder contains 610.3 ± 1 mg/kg and in egg yolk powder (548.3 ± 2 mg/kg) and followed by egg white powder contains (462.4 ± 3 mg/kg) of sodium and the whole egg powder contains (458.9 ± 5 mg/kg) magnesium. The results showed the selenium of (131.65 ± 3 mg/kg) rich in egg white powder and followed by whole egg powder (102.6 ± 3 mg/kg).

The food and drug administration regulations require nutrition labelling for most foods. Reference of daily intakes for some essential elements of human nutrition and daily reference values have been established, namely: Ca (1000 mg), Cl (3400 mg), Cu (2 mg), Fe (18 mg), K (3500 mg), Mg (400 mg), Mn (2 mg), P (1000 mg) and Zn (15 mg)[7]. So the measurements of major and trace metal is also very helpful in assessment of quality of dry egg powder during production in manufacturing industries.

Conclusion

From the results, it is seen that elements As, Hg, Se, Zn, P, Pb, Cd, Fe, Mn, Cr, Mg, Cu, Ca, Na and K) have been successfully be determined in the dehydrated egg powdered samples by using ICP-OES with microwave digestion procedures. The use of ICP-OES provides a simpler, effective, faster and less contamination procedure of determining the quality of egg powders. The results show that egg powder is a good source of calcium sodium, potassium, magnesium, selenium and phosphorous and egg powder was a very important human nutrient since their consumption has increased in recent years.

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REFERENCES

1. L.A. Walker, T. Wang, H. Xin and D. Dolde, *J. Agric. Food Chem*., 60, (1999).
2. N.N. Prasad, M.S.L. Swamy, K.R. Viswanathan and K. Santhanam, *J. Food Sci. Technol*., **41**, 534 (2004).
3. S. Kumaravel, R. Hema and A. Kamaleshwari, *New York Sci. J*. **4**, 1 (2011).
4. A.R. Date and A.L. Gray, *Analyst*, **108**, 159 (1983).
5. D. Bakircioglu, Y.B. Kurtulus and G. Ucar, *Food Chem. Toxicol*., **49**, 202 (2011).
6. P.F. Surai and N.H.C. Sparks, *Trends Food Sci. Technol*., **12**, 7 (2001).
7. S.P. Dolan and S.G. Capar, *J. Food Compos. Anal*., **15**, 593 (2002).