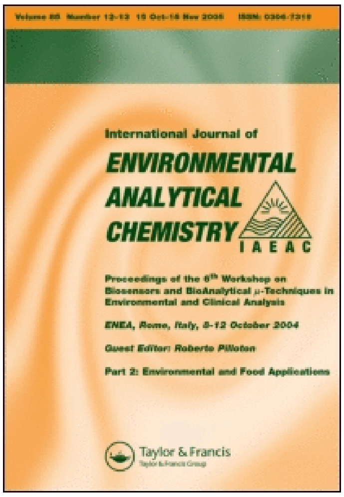

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Determination of Trace Elements of Egyptian Cane Sugar (Naga Hammady Factories) by Neutron Activation, Atomic Absorption Spectrophotometric and Inductively Coupled Plasma-Atomic Emission Spectrometric Analyses

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Determination of Trace Elements of Egyptian Cane Sugar (Naga Hammady Factories) by Neutron Activation, Atomic Absorption Spectrophotometric and Inductively Coupled Plasma-Atomic Emission Spectrometric Analyses

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INAA, AAS and ICP-AES techniques are applied to the determination of trace amounts of Ag, Al, As, Au, Ba, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Ga, Hf, K, La, Li, Lu, Mg, Mn, Na, Nb, Ni, Pb, Sb, Sc, Se, Sm, Sn, Sr, Ta, Th, Ti, U, V, W and Zn in the stalks of sugar cane plant after extracting juice, raw juice principal (mixed) juice, juice withdrawn from the successive stages of sugar industry, sirup, deposits from evaporators, molasse, A-? and B-sugar and in the soil samples (collected from the field supplying the factories by cane plants) taken from the immediate vicinity of the plant roots at surface, 30 and 60 cm depth. The results obtained are in a good agreement of the safety baselines of using juice as beverage, molasse derivatives (honey, sweets,...) as diet for common people in the developed countries and in industry (methanol, ethanol, acetone & acetic acid,...) and sugar sweeting for many purposes (in beverages, desserts,...). Differences of trace elements concentrations in soil samples may be reasoned to geochemical and biogeochemical fractionation while those in juice may be due to the changes in the environmental conditions, chemical composition and botanic structures. Variations in trace element contents in the products formed during the successive stages of sugar industry may be a result of evaporation, filtration processes, chemical treatments or corrosion of vessels, containers or engines. Trace elements are very important where they are responsible for enzymatic and biochemical reactions, matabolism, health and diseases.

KEY WORDS: Trace elements, sugar cane, neutron activation, atomic absorption spectrometry, inductively coupled plasma-atomic emission spectroscopy.

INTRODUCTION

The study of trace elements is of interest where trace element analysis is the key for recognising their vital important roles on life cycles, biochemical and enzymatic reactions in plants, animals, fishes and human beings as well as their roles in geochemistry, biogeochemistry, ore deposits and in the genetic relations between the different types of rocks.

The present work is part of a comprehensive program planned to study the trace elements in soil, sediments, water, crops, plants, vegetables, fruits, cane sugar, milk, foods, coffee and tea and to monitor the trace element level to follow up the lack or deficiency of trace elements in soil, mud, water, crops and plants after the construction of Aswan High Dam, which may possibly inhibit or block growth and increase susceptibility to plant diseases and pests, which decrease crops production.

Trace elements were determined by INAA in water,[2-5] water and sediments,[6-10] coffee and tea,[11,12] food,[13,14] organic [15] and biological[16,17] materials, aerosols,[18] rocks,[19,20] air,[21] oil,[22] hair,[23] blood,[24,25] crops,[26-28] atmosphere,[29] cane sugar,[30-33] human liver,[34] opium and canabis,[35] and in soil,[36] by AAS in chicken eggs,[37] fruit juice,[38] crude meat samples,[39] some canned fruits and vegetables[40] and in pig faeces,[41] and by ICP-AES in sea water,[42] near-shore marine sediments,[43.44] geological materials[45] and in raw agricultural crops,[46]

EXPERIMENTAL

Samples collection

Two raw juice samples, the stalks of sugar cane plant taken from the field (after extracting juice and before treatment), principal (mixed) juice, juice samples withdrawn during the successive stages of operation, sirup from evaporators, molasse and A- and B-sugar as well as in the soil samples taken from the immediate vicinity of the plant roots at surface, 30 and 60 cm depth. The samples were collected in May 1980. The different operational stages of sugar industry can be summarised as follows:

Stage 1: principal juice. Stage 2: diffusion juice (it is obtained on cutting the stalks of sugar cane plants into small pieces and heating the resultants to a relatively high temperature where sugar contents diffuse when dilute sugar solution passes through the mixture). Stage 3: juice + $Ca(OH)_2$. Addition of $Ca(OH)_2$ is to flocculate and coagulate colloidal and suspended matter. Stage 4: juice + superphosphate + SO_2 (addition of superphosphate is to form flocculent precipitates of $Ca_3(PO_4)_2$, $CaSO_4$, $CaSiO_3$, $AlPO_4$, $FePO_4$ and $Mg(OH)_2$. $Mg_3(PO_4)_2$ which entrain much of the very fine suspended matter and on settling, a clear juice is obtained, while the action of SO_2 on juice is considered to be bleaching the brown colour of juice due to the presence of aminoacids, pectines, waxes, proteins, resins, fats,... etc., it is also considered to be neutralising and viscosity reducing). Stage 5: clear juice (after filtration). Stage 6: turbid juice. Stage 7: sirup without SO_2. Stage 8: sirup with SO_2(SO_2 for bleaching sirup for production of white sugar which is used for direct consumption). Stage 9: molasse. A(99.7%)- and B(99.3%)-sugar.

Materials: Super pure HNO_3, HF, HCl, $HClO_4$, CH_3COOH acids, As_2O_3 and $Pb(AcO)_2$ (Merck, 99.9%) and thrice distilled water.

Standards: Biological[47] [Bowen's kale (OK), Orched leaves (OL) and Tomato Leaves (TOML)] and Geological [Coal Fly Ash (CFA), Stromboli (STR)[48] and Granite (USGS $-G_2$)[19]] standards.

Apparatus

Gamma Spectrometer Nuclear Data ND-66(2 × 4096 channels), Ge(Li) Detector, 40 cm^3, Resolution 3.8 Kev.

Minicomputer; DEC, PDP 11−04, −34, −45.

Perkin–Elmer Double Beam Atomic Absorption Spectrophotometer Model-303 equipped with a Boling Air- Acetylene Burner.

Inductively Coupled Plasma Atomic Emission Computerised Spectrometer.

Teflon Crucibles, Electrical Furnace, Sand Bath, Infrared Lamp, Polyethylene Vials and Capsules, Micropipettes, Measuring Flasks and Polyethylene & Glass Beakers.

Working procedure

(A) *Sample preparation for INAA*:

(1) Juice and Molasse samples: One litre of juice or molasse samples was evaporated on a water bath down to the homogenous state. 2 g of the dried samples were dissolved in supra- pure nitric acid in a teflon crucible and evaporated to dryness. The residue was placed into polyethylene vials which were then properly sealed using the technique reported by Brandstatter *et al.*[49]

(2) The plant, sugar, deposit and soil samples: The samples were dried in an electric furnace at 100°C for three hours. The samples after cooling, were powdered. 0.5–2 g of the dried cana plant, sugar or deposit samples and 100 mg of the representative coil (prepared by quartering method[50]) samples were inserted in small polyethylene vials and the vials were closed in a special method using a welding apparatus.[49]

(B) *Sample preparation for AAS*:

(1) Juice, Molasse and sugar samples: 4 g of the homogenous dried samples of each of juice, molasse or sugar were dissolved in 40 ml HNO_3 in teflon crucible. The crucible was covered with a watch glass and placed on a sand bath until complete destruction of the sample was reached whereby a clear solution was obtained then the solution was made up to 100 ml using thrice distilled water.

(2) Soil samples: One gram sample was brought into solution by dissolving it in 10 ml HNO_3 + 10 ml HCl in teflon crucible. The crucible was placed on a sand bath and heated near dryness. The residue was dissolved in 10 ml HNO_3 + 10 ml HCl then heated to dryness. 10 ml of 2N HCl were added to the residue and the crucible was heated for three minutes on a sand bath. The crucible was cooled, then the cover was rinsed, washed and transferred into the

original solution and then the solution was filtered. The filtrate was made 100 ml using thrice distilled water.

Standard solutions and calibration graphs

1 mg As_2O_3/ml was obtainable by dissolving 1 g of As_2O_3 in few drops of HF in a teflon crucible then the solution was transferred and made up to one litre using thrice distilled water. 1 mg Pb/ml was prepared by dissolving the appropriate amount of Pb $(AcO)_2$ in few drops of AcOH, then the solution was diluted to one litre using thrice distilled water. The standard curves for As and Pb were constructed by representing the absorbance-concentration relationship.

Sample preparation for ICP-AES

Soil samples taken in 0.5 g were dissolved in a mixture of HCl and $HClO_4$, whereas molasse, juice, sirup and the different types of sugar samples solutions were prepared following the same technique applied for estimation of As and Pb by AAS method.

Irradiation and measurement

The samples were irradiated inside the reactor at 250 KW using neutron flux equals 7.5×10^{13} n.cm^{-2}.sec^{-1} (iron wire monitor was used for flux correction) in the case of long ($ti = 24$–48 h, $t_d = 2$–3 w and $t_c = 15$–60 min) and medium radioactive nuclides ($t_i = 3.5$–6 h, $t_d =$ 12–40 min, $t_c = 10$–30 min), 5×10^{12} n.cm^{-2}.sec^{-1} in the case of the short lived radioactive nuclides (slow pneumatic transfer rabbit system, $t_i = 30$ s–2 min, $t_d = 2$–3 min, $t_c = 10$ min) and 1.3×10^{12} n.cm^{-2}.sec^{-1} in the case of the short lived nuclides (fast pneumatic transfer and measure mini system, $t_i = 10$–20 s, $t_d = 0$–50 s, $t_c = 5.1$, 81.6 or 255 s). The peak-to-background ratios may be derived from the semi-log plots of the spectra. Some of the results were corrected for overlapping γ-lines.

RESULTS AND DISCUSSION

The results of INAA, AAS and ICP-AEC measurements are given in Tables I–V.

TABLE I
Trace element concentration in juice, molasses and sugar samples (Naga Hammady factories) using INAA.

Element	Juice 1	Juice 2	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Al (ppm)	6.3	19.1	82.7	27.0	43.9	2.8	11.3
Au (ppb)	0.10	0.08	0.13	0.11	0.09	0.10	0.07
Br (ppb)	752.1	207.2	279.2	379.1	639.5	524.1	848.8
Ca %	0.16	0.10	0.08	0.35	0.53	0.50	0.91
Cl %	0.12	0.70	0.73	1.1	1.5	0.60	1.3
Co (ppb)	14.6	20.4	33.0	28.7	90.8	8.6	18.1
Cr (ppb)	40.5	28.1	35.4	135.7	46.3	49.3	58.2
Eu (ppb)	1.1	2.3	2.2	1.5	1.5	2.1	1.2
Fe (ppm)	317.3	450.4	611.7	870.2	889.3	—	920.1
K %	1.8	2.0	1.2	1.7	1.6	1.3	2.8
La (ppb)	4.3	3.8	3.8	4.9	1.8	1.0	0.78
Lu (ppb)	1.0	2.1	1.9	2.6	1.5	1.3	0.63
Mg %	0.05	0.12	0.16	0.19	0.23	0.09	0.24
Mn (ppm)	1.2	11.0	24.1	35.1	40.5	12.3	16.2
Na %	0.15	0.10	0.11	0.76	0.31	0.12	0.08
Sb (ppb)	—	—	39.8	40.3	70.4	121.8	—
Sc (ppb)	8.3	12.1	10.2	16.8	25.9	20.3	32.9
Sm (ppb)	1.2	3.3	2.9	3.2	1.4	2.1	2.7
V (ppb)	—	—	339.1	—	447.4	432.9	710.6

TABLE I (*continued*)

Element	Stage 6	Stage 7	Stage 8	Molasse	A-sugar	B-sugar
Al (ppm)	242.6	140.9	3.5	14.1	4.1	3.8
Au (ppb)	0.04	0.02	0.01	0.10	—	—
Br (ppb)	252.6	162.8	328.8	479.4	54.3	59.4
Ca %	0.13	0.38	0.87	0.90	0.82	0.93
Cl %	0.51	0.92	0.44	1.3	0.003	0.004
Co (ppb)	7.9	8.6	6.3	28.4	—	—
Cr (ppb)	49.5	196.5	107.5	49.4	—	—
Eu (ppb)	2.9	0.90	0.98	2.2	—	—
Fe (ppm)	72.3	69.3	51.9	74.8	14.5	19.2
K %	1.5	2.1	1.1	2.9	—	0.07
La (ppb)	2.2	0.98	1.6	2.2	—	—
Lu (ppb)	1.9	0.87	1.0	1.1	—	—
Mg %	0.11	0.09	0.07	0.20	0.01	0.03
Mn (ppm)	49.5	37.1	5.0	14.6	—	0.12
Na %	0.10	0.04	0.05	0.09	7.7(ppm)	8.1(ppm)
Sb (ppb)	104.8	—	40.8	18.4	—	—
Sc (ppb)	34.3	16.8	12.8	52.2	2.3	4.4
Sm (ppb)	1.6	—	—	1.3	—	—
V (ppb)	1223.5	739.9	264.2	729.3	—	—

TABLE II
Trace elements concentration in sugar cane plant samples (Naga Hammady).

Element	Plant 1	Plant 2	Mean
Al (ppm)	595.7	617.2	606.5
As (ppb)	17.3	21.4	19.4
Au (ppb)	0.14	0.17	0.16
Br (ppm)	3.6	4.8	4.2
Ca (ppm)	790.9	817.3	804.1
Cl %	0.25	0.33	0.29
Co (ppb)	43.8	36.2	40.0
Cr (ppb)	66.7	53.7	60.2
Fe (ppm)	278.1	256.2	267.2
K %	0.26	0.33	0.30
La (ppb)	32.9	43.1	38.0
Lu (ppb)	7.4	6.1	6.8
Mg %	0.87	0.19	0.53
Mn (ppm)	5.5	3.3	4.4
Na (ppm)	182.3	193.6	188.0
Se (ppb)	28.1	21.7	24.9
Sc (ppb)	3.8	2.9	3.4
U (ppb)	5.2	3.6	4.4
V (ppb)	115.6	114.8	115.2
W (ppb)	11.8	14.5	13.2

The results show that Al, Br, Ca, Cl, Fe, K, Mg and Na are enriched in the soil as well as in the plant while Au, Lu and U are less enriched in plant and in soil but Co, Cr, La and V are less concentrated in plant than in soil. Br, Cl, Co, Cr, Fe, K and V increase in the different stages of sugar industry up to stage 6 (and in molasse) then they decrease and reach minimum in B-sugar, however, A-sugar contains nothing. Crude juice contains nothing of As, Pb, Sb and V as well as A(0.3 ppb Pb)- and B(0.7 ppb Pb)-sugar. In addition, A- and B-sugars are free from Au, Co, Cr, Eu, K, La, Pb, Sm and V. Appearance of As, Pb, Sb and V in the processing stages of sugar industry may be due to corrosion effects of vessels, containers and machine tools or occasionally to addition of chemicals. Absence of As, Cd, Cr, Pb, Sb and V from sugars renders the supply of sugar to be safe. The presence of Ca, Fe, Cu, Mn, Zn and Co in the analysed plants, crude juice, sirup and molasse have

TABLE III
Trace elements concentration in soil samples (Naga Hammady section)

Sample no. and depth	Sample 1			Sample 2				
Element	Surface	30 cm	60 cm	Surface	30 cm	60 cm	Mean	R.E.%
Al %	8.5	10.2	8.5	13.0	10.5	11.7	10.4	±0.3
Au (ppb)	9.3	10.2	9.6	7.3	7.3	7.7	8.6	±6.6
Ba (ppm)	642.0	—	407.6	—	647.1	794.0	622.7	±12.2
Br (ppm)	32.6	30.1	39.7	31.6	34.0	32.9	33.5	±11.1
Ca %	5.1	5.4	5.1	4.8	4.9	4.9	5.0	±8.7
Ce (ppm)	98.2	106.7	100.3	116.1	123.6	117.0	110.3	±2.8
Cl %	0.13	0.11	0.14	0.14	0.12	0.17	0.13	±2.3
Co (ppm)	38.3	45.6	42.6	46.0	45.6	43.3	43.5	±8.1
Cr (ppm)	242.0	264.2	251.0	228.3	226.9	221.4	239.0	±7.5
Cs (ppm)	2.0	2.0	2.2	1.6	1.5	1.8	1.9	±6.9
Dy (ppm)	1.7	1.2	—	—	—	—	1.5	±12.1
Eu (ppm)	2.7	3.1	3.1	3.1	3.4	3.3	3.1	±4.6
Fe %	10.1	11.0	10.7	10.8	11.2	11.0	10.8	±4.3
Hf (ppm)	9.0	8.5	8.5	8.1	8.2	8.4	8.5	±7.2
K %	1.8	1.2	1.5	1.4	1.3	1.1	1.4	±6.4
La (ppm)	32.2	35.8	34.5	36.6	40.0	39.1	36.4	±5.5
Lu (ppb)	219.4	315.7	306.0	390.0	401.1	361.1	332.2	±10.0
Mg %	2.6	3.0	2.6	3.0	2.7	2.7	2.8	±7.9
Mn %	0.12	0.20	0.13	0.21	0.18	0.20	0.17	±9.7
Na %	1.0	2.0	1.9	1.4	1.5	1.4	1.7	±4.6
Ni (ppm)	10.0	14.9	11.8	19.8	20.0	17.9	15.7	±7.4
Sb (ppm)	8.4	9.7	10.1	11.8	12.8	12.8	10.9	±6.3
Sc (ppm)	30.4	33.3	32.0	34.0	36.0	34.6	33.4	±0.8
Sm (ppm)	10.8	12.4	11.8	12.4	13.6	13.0	12.3	±0.8
Ta (ppm)	7.6	8.0	8.0	8.3	9.0	8.5	8.2	±3.6
Th (ppm)	4.9	5.7	6.2	6.6	6.2	6.8	6.1	±5.8
Ti (ppm)	487.4	529.7	642.7	565.0	—	661.3	577.2	±11.3
U (ppb)	32.2	31.7	30.1	28.8	30.1	33.2	31.0	±2.3
V (ppm)	200.0	224.7	188.4	260.7	210.0	241.3	220.8	±8.6
Zn (ppm)	65.9	78.1	64.1	66.2	73.3	77.3	70.8	±5.9

shown to be nutritionally essential elements for life of higher forms of animals, plants and human beings.[51] Also, the interaction between the elements Cu; Zn-Fe; Mn- Fe; As- Se; Mn- La[1] present in the investigated samples may reflect the important role of the dietary balance among these trace elements in growth of plants, in nutrition and in health and disease. The taste, colour and smell of some plants

TABLE IV

Results of the analysis of cane sugar juice, molasse and sugar samples using ICP method and AAS for the determination of AS&Pb. (Naga Hammady factories)

Element	Juice 1	Juice 2	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	Stage 9	A-sugar	B-sugar
Al %	0.00	0.00	0.03	0.10	0.15	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Ca %	1.73	1.31	1.38	10.97	17.36	1.36	10.51	7.93	3.53	1.63	3.60	1.14	1.14
Co %	0.0000	0.0001	0.0001	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000
Cr %	0.0000	0.0000	0.0000	0.0001	0.0014	0.0000	0.0001	0.0000	0.0002	0.0000	0.0007	0.0000	0.0000
Cu %	0.0042	0.0043	0.0029	0.0099	0.0247	0.018	0.0018	0.0119	0.0006	0.0004	0.0035	0.0002	0.0007
Fe %	0.34	0.34	0.16	0.22	0.53	0.08	0.12	0.33	0.05	0.02	0.070	0.000	0.00
Ga (ppb)	4	5	6	0	0	2	0	0	0	0	8	0	0
K %	11.51	13.81	10.81	23.18	0.00	9.59	19.71	5.30	5.80	5.00	7.93	0.00	0.07
Li (PPb)	10	8	6	0	0	0	0	0	0	0	15	0	0
Mg %	1.59	1.47	1.33	1.95	3.57	0.99	2.11	0.77	0.68	0.55	0.87	0.03	0.04
Mn %	0.008	0.015	0.022	0.039	0.054	0.015	0.015	0.031	0.005	0.004	0.007	0.000	0.000
Na %	0.293	0.107	0.361	1.406	2.378	0.721	1.702	0.458	0.507	0.437	0.628	0.011	0.014
Nb (ppb)	1	0	2	2	3	0	0	0	0	0	8	0	0
P %	0.416	0.409	0.474	1.261	1.601	0.210	0.061	1.248	0.070	0.039	0.088	0.027	0.015
Sn (ppb)	0.9	1.1	1.7	1.9	4.3	0.0	1.4	0.0	0.0	0.0	5.5	0.0	0.0
Sr %	0.0091	0.0081	0.0100	0.0320	0.0380	0.0165	0.0212	0.0212	0.0109	0.0045	0.0073	0.0021	0.0032
V (PPb)	28	20	30	62	92	25	72	58	35	19	33	5	9
Zn (ppb)	130	131	112	134	224	74	84	79	43	29	122	25	21
As (PPb)	—	—	0.69	0.62	0.53	0.49	0.42	0.58	0.61	0.57	0.92	—	—
Pb (ppb)	—	—	1.3	2.0	1.3	—	3.3	6	2	1.3	3.3	0.7	0.3

TABLE V
Results of analysis of soil samples using ICP method and AAS for As&Pb (Nagga Hammady district)

Sample no. and depth	Sample 1			Sample 2		
Element	Surface	30 cm	60 cm	Surface	30 cm	60 cm
Ag (ppm)	0.14	0.18	0.18	0.20	0.23	0.18
Al %	10.47	12.04	11.69	12.88	13.11	12.09
Ba %	0.075	0.054	0.081	0.096	0.112	0.87
Be (ppm)	4	5	5	5	5	4
Ca %	3.86	4.22	4.06	3.70	3.65	3.23
Cd (ppm)	0.15	0.18	0.18	0.18	0.19	0.17
Ce %	0.0082	0.0093	0.0093	0.0100	0.0108	0.0098
Co %	0.0035	0.0042	0.0040	0.0039	0.0042	0.0036
Cr %	0.0135	0.0154	0.0160	0.0143	0.0156	0.0122
Cu %	0.0056	0.0061	0.0064	0.0065	0.0067	0.0058
Fe %	7.11	8.18	8.04	8.15	8.54	7.52
Ga (ppm)	11	10	10	12	12	12
K %	1.12	1.06	1.07	1.08	0.99	0.89
La (ppm)	41	45	45	48	50	45
Li (ppm)	12	5	6	4	8	0.0
Mg %	2.37	2.66	2.60	2.74	2.66	2.44
Mn %	0.125	0.149	0.143	0.182	0.173	0.149
Na %	1.462	1.507	1.580	1.351	1.402	1.208
Nb (ppm)	17	17	20	22	22	21
Ni %	0.0061	0.0073	0.0071	0.0073	0.0081	0.0068
P %	0.169	0.160	0.162	0.175	0.170	0.147
Sb (ppm)	5.4	7.5	7.6	7.1	7.9	5.7
Sc (ppm)	25	29	28	24	30	27
Sn (ppm)	0.4	0.0	0.0	0.0	0.0	0.0
Sr %	0.0407	0.0439	0.0438	0.05414	0.407	0.0378
Ti %	1.679	1.956	1.939	1.742	1.822	1.599
V (ppm)	246	243	286	260	275	249
Zn (ppm)	66	71	73	65	77	63
As (ppb)	43.5	42.0	44.2	73.0	70.5	71.2
Pb (ppb)	45.0	43.9	46.0	45.0	44.0	48.0

may be attributed to the presence of some trace elements such as La, Mn,...[52] In addition, the physiological effects of elements such as Zn, Cu, Fe, Co, Ni, Mn, Se,... are reported.[53, 54] The presence of chromium in trace amounts (ppb) in crude juice, treated juice and molasse is conformable with the recent findings of Cr^{3+} as an essential element for mamalian sugar metabolism.

Based on the analysis of raw juice, treated juice, molasse and sugar, one can distinguish four types of group elements.

1—Al, Ca, K, Mg, Mn, and Na have no distinct trend through the course of sugar production.
2—La and Sc increase significantly during the different stages of sugar production.
3—Au and V show of significant decrease in the successive stages of sugar industry.
4—Br, Cl, Co, Cr, Na and Sm show one or more distinct maxima, characterising the relations between the elements determined.

In the case of soil samples, one can also distinguish four types of relations between the elements determined:

1—Al, Hf, K and Th have relatively high concentrations on the surface.
2—Concentrations of Au, Br, Ce, Eu, Fe, Mg, Na, La, Lu, Ta, Ti, Sc and Zn increase with the depth. The decrease of the concentration of these elements on the surface of the soil may be due to the preferential and selective uptake and assimilation of these elements by plants.
3—Cl, Cs and Ca show no distinct change at different depths.
4—Lu, Mn, Sc, Sm, V and U have irregular distribution without showing a distinct trend in the soil. Variations of trace element concentrations in soil samples may be due to geochemical and biogeochemical fractionation of soil while those in crude juice and in the stalks of sugar cane plants may be due to environmental changes, variations in botanic forms and structures, and in chemical composition of plant.

CONCLUSION

There is a marked effect of trace elements present in soil on the composition of crude juice as well as treated juice, molasse, deposit and sugar as a result of evaporation, filtration processes, and chemical treatments. In addition, corrosion of vessels containing juice, sirup and molasse has a more or less significant effect. However, trace elements present in crude juice, molasse and sugar are below hazardous or toxic levels.

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