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Determination and Evaluation of the Mineral Composition of Chinese Cabbage (*Beta vulgaris*)

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Abstract Inductively coupled plasma optical emission spectrometry was used to determine the elements present in Chinese cabbage (*Beta vulgaris*). The accuracy of the method was confirmed by analysis of a certified reference material of spinach leaves. The study involved 57 samples that were collected in 13 Brazilian cities. Average concentrations of elements found per gram of Chinese cabbage were as follows: 3.44 mg g^{-1} sodium, 5.09 mg g^{-1} potassium, 1.25 mg g^{-1} phosphorous, 0.85 mg g^{-1} calcium, 0.49 mg g^{-1} magnesium, 2.79 μg g^{-1} manganese, 9.50 μg g^{-1} iron, 0.74 μg g^{-1} copper, 14.28 μg g^{-1} zinc, and 6.44 μg g^{-1} strontium. Principal component analysis and hierarchical cluster analysis demonstrated that there is no systematic difference in the mineral composition between the cabbage samples that were analyzed.

Keywords Nutrients · Mineral composition · Chinese cabbage · Inductively coupled plasma optical emission spectrometry · PCA · HCA

Introduction

Evaluating the composition of human food, such as vegetables, fruits, leaves, and roots, has often been required. Data consisting of inorganic and organic nutrients found in these foods are important to nutritionists and doctors. Nutrient information can also contribute to the formulation of food composition tables. Several studies have been performed to investigate the composition of food (Salahinejad and Aflaki 2010; Feliciano et al. 2009; Mendil et al. 2009; Soylak and Turkoglu 1999). For instance, Kelly and coworkers determined and compared mineral concentrations found in commercially grown organic and conventional crops of tomatoes and lettuces (Kelly and Bateman 2010). Another paper determined the mineral composition of 23 plants, including the arial parts, leaves, bark, stems, roots, rhizomes, dried berries, and seeds used in indigenous medicinal food (Bhat et al. 2010). Aberoumand (2009) determined the content of iron, potassium, sodium, calcium, and zinc in the leaves and stems of *Portulaca oleracia* L.

Chinese cabbage (*Beta vulgaris*), also known as Japanese chard, is a leafy vegetable often consumed as a food supplement in diets recommended for weight loss. Kawashima and Soares determined the presence of several mineral nutrients in Chinese cabbage. The results are as follows, with 100 g representing fresh weight: 228 mg K/100 g, 5 mg Na/100 g, 47 mg Ca/100 g, 13 mg Mg/100 g, 0.20 mg Fe/100 g, 0.23 mg Zn/100 g, 0.05 mg Mn/100 g, and 0.04 mg Cu/100 g (Kawashima and Soares 2003). Milacic and coworkers performed a speciation analysis of aluminum in the roots of Chinese cabbage (Bantan-Polak et al. 2005). Other authors determined antioxidant potential, anti-proliferative activity, and phenolic content in water-soluble fractions of some commonly consumed vegetables, including Chinese cabbage (Roy et al. 2007). Prasad and Chetty (2008) performed a flow injection analysis method for the determination and evaluation of nitrate in fresh leafy vegetables, such as Chinese cabbage, celery, lettuce, and English cabbage.

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Principal component analysis (PCA) is a multivariate analysis technique that determines the diagonalization of the covariance or correlation matrix, thereby transforming the original chemical measurements into linear combinations (Sharaf et al. 1986). This technique simplifies the graphical representation of the data by reducing the variance from higher to lower dimensional spaces. Thus, PCA has often been employed for the evaluation and characterization of elements in foods such as milk (Nascimento et al. 2010), wine (Pereira et al. 2010), olive oil (Fasciotti and Netto 2010), leaves (Fadigas et al. 2010; Lima et al. 2010), coffee (Korhonova et al. 2009), meat and fish (Spiric et al. 2010), and others (Choi et al. 2009).

Hierarchical cluster analysis (HCA) is another technique used for the evaluation of analytical data. This technique helps determine similarities between samples by examining the interpoint distances representing all possible sample pairs in higher dimensional space. The sample similarities are represented on two-dimensional diagrams called dendrograms. PCA and HCA are complementary and have been used to confirm results observed for each of these (Yuan et al. 2010; Pasha et al. 2010).

In the present paper, the mineral composition of the Chinese cabbage was determined using the technique of inductively coupled plasma optical emission spectrometry and was evaluated using the multivariate analysis techniques of PCA and HCA.

Experimental

Instrumentation

A Varian model Vista PRO Inductively Coupled Plasma Optical Emission Spectrometer (Mulgrave, Australia) with axial viewing and a charge-coupled device detector was used for multi-element determination. A Sturman–Master chamber and a V-Groove nebulizer were also utilized. Element determinations were carried out under the followings instrumental conditions: power (1.3 kW), plasma gas flow (15.0 L min^{-1}), auxiliary gas flow (1.5 L min^{-1}), and nebulizer gas flow (0.8 L min^{-1}). The elements and analytical wavelengths used for quantification were as follows: Ca II (317.933 nm), P I (213.613 nm), K II (766.491 nm), Na I (589.592 nm), Mg II (285.213 nm), Fe II (238.204 nm), Mn II (259.372 nm), Cu I (324.754 nm), Sr II (421.552 nm), and Zn II (202.548 nm).

Chemicals and Reagents

All chemical reagents used in the experiment were of analytical grade. Ultra pure water (18.2 MΩ cm) from a Milli-Q system (Millipore, MA, USA) was used to prepare all solutions. The glass apparatuses used were decontaminated in a 10% *v*/*v* nitric acid solution for 12 h prior to use.

Unless otherwise stated, all chemicals used were purchased from Merck (Darmstadt, Germany). Standard stock solutions for all elements with a concentration of 1,000 mg L^{-1} were used to prepare working standard solutions by diluting each of these solutions with 1% (*v*/*v*) nitric acid. Solutions of nitric acid and hydrogen peroxide were used for sample digestion.

Sample Collection and Storage

The samples were collected in the following Brazilian cities: Jaguaquara (JAG), Salvador (SSA), Maceió (MC), Conceição de Jacuipe (CJ), Vitoria (VIT), Campinas (CAM), Maracanaú (MAR), Fortaleza (FOT), São Paulo (SPA), Serra Talhada (SET), Aracaju (ACJ), Recife (REC), and Natal (NAT). The samples were refrigerated to prevent the proliferation of fungi and bacteria. A plastic grater was used in the partitioning of samples to avoid metal contamination. Samples were packed and grated into small plastic pots with mechanical agitation (manual) using plastic pallets to homogenize the samples.

Sample Digestion

Approximately 2.0 g of each sample was placed into glass vessels. Three milliliters of concentrated nitric acid and 3.0 mL of 30% (*v*/*v*) hydrogen peroxide were added to each vial. The samples were digested for 3 h at 140°C. The digested samples were later transferred to 15-mL centrifuge tubes and topped off with ultrapure water up to the 12-mL mark.

Accuracy of the Analytical Method Used for Quantification

A certified reference of spinach leaves (National Institute of Standards and Technology, Gaithersburg, MD, USA) was

Table 1 Evaluation of the accuracy of the analytical method used for quantification

Element	Achieved value	Certified value
K (%)	2.887±0.583	2.903±0.052
Na (%)	1.777±0.367	1.818±0.043
Ca (%)	1.448±0.277	1.527±0.041
P (%)	0.496±0.126	0.518±0.011
Mg (%)	0.86±0.144	0.89[a]
Zn (mg kg^{-1})	80±12	82±3
Mn (mg kg^{-1})	67.3±5.2	75.9±1.9
Sr (mg kg^{-1})	53.22±1.77	55.6±0.8

[a] Value reported

Table 2 Determination of the mineral composition of Chinese cabbage samples

Sample	Ca[a]	Mg[a]	Na[a]	P[a]	K[a]	Cu[b]	Sr[b]	Mn[b]	Fe[b]	Zn[b]
2A-JAG1	0.80	0.41	3.15	1.46	6.24	1.36	4.53	5.22	12.60	8.25
2A-JAG2	1.02	0.48	3.81	1.60	7.98	1.41	5.78	5.89	12.86	9.15
2A-JAG3	0.74	0.34	2.55	1.16	5.16	0.86	4.05	4.75	9.03	6.84
2A-MC11	1.33	2.41	5.08	1.84	6.27	1.12	6.87	4.62	14.61	8.99
2A-MC12	1.31	2.25	5.24	1.56	5.87	1.18	7.08	4.30	12.88	6.23
2A-MC13	1.00	2.01	4.43	1.32	5.23	0.72	5.50	3.11	9.39	4.65
2A-SSA1	0.71	0.28	3.05	1.32	5.20	0.72	3.91	3.38	10.75	15.09
2A-SSA2	0.74	0.29	3.45	1.26	5.51	0.72	4.38	3.20	10.64	13.58
2A-SSA3	0.86	0.27	3.56	1.10	5.41	0.57	4.93	3.02	8.37	11.78
2A-MC21	1.39	0.35	5.53	1.56	5.91	0.80	7.75	3.56	9.49	15.52
2A-MC22	1.54	0.39	5.80	1.62	6.41	0.86	8.47	4.10	9.90	15.94
2A-MC23	1.17	0.35	4.93	1.93	6.47	1.19	5.89	4.10	13.24	20.40
2A-CJ 1	0.63	0.35	1.71	1.26	4.95	1.02	2.81	3.52	13.39	17.28
2A-CJ 2	0.71	0.28	1.38	0.93	4.45	0.54	4.08	2.53	7.78	10.83
2A-CJ 3	0.69	0.30	1.47	1.04	4.54	0.72	3.55	3.00	10.10	13.19
1A-VIT1	1.17	0.28	3.15	1.39	5.84	0.77	4.96	2.88	9.17	41.95
1A-VIT2	1.20	0.27	2.15	1.27	5.89	0.67	5.11	2.62	7.66	15.50
1A-VIT3	1.09	0.23	1.88	1.14	4.97	0.80	4.78	2.41	7.19	12.21
1A-CAM1	1.01	0.32	1.50	1.42	5.38	1.08	9.48	2.99	10.22	14.31
1A-CAM2	1.01	0.29	1.12	1.21	4.63	0.87	9.64	2.70	7.76	9.67
1A-CAM3	0.83	0.28	1.68	1.35	5.33	0.98	7.57	2.75	8.79	11.13
1A-MAR1	0.70	0.39	2.78	1.63	7.26	0.92	3.77	0.96	8.95	18.05
1A-MAR2	0.76	0.48	3.20	2.00	9.15	1.23	3.68	1.07	12.72	23.78
1A-MAR3	0.84	0.45	3.63	1.63	8.50	0.90	4.63	0.95	9.52	18.09
1A-FOT1	0.66	0.32	4.43	1.61	5.86	0.85	4.11	4.49	7.67	16.12
1A-FOT2	0.75	0.37	4.99	1.65	6.04	2.21	4.54	4.81	7.90	16.08
1A-FOT3	0.70	0.37	4.33	1.71	5.72	1.09	4.02	4.79	9.51	17.96
1S-SPA1	0.72	0.23	2.26	1.03	4.37	0.57	7.04	2.02	9.17	13.24
1S-SPA2	0.79	0.26	3.44	1.22	4.89	0.72	7.69	2.28	13.26	14.20
1S-SPA3	0.98	0.31	3.81	1.38	5.26	0.82	10.04	2.67	12.83	21.23
1S-CJ11	1.19	0.26	3.53	1.05	4.79	0.16	10.49	1.66	5.53	9.64
1S-CJ12	0.76	0.25	2.81	1.17	4.70	0.40	6.27	2.07	9.08	13.24
1S-CJ13	0.60	0.19	2.18	0.91	3.82	0.32	5.13	1.60	6.70	11.78
1S-CJ21	0.29	0.25	5.73	0.98	4.16	0.74	10.58	1.93	9.59	12.08
1S-CJ22	0.29	0.27	5.50	1.10	4.43	1.20	10.74	2.26	10.96	12.65
1S-CJ23	0.25	0.24	5.13	1.11	4.42	0.66	9.01	2.05	10.24	13.62
1S-JAG1	0.86	1.71	2.26	0.75	3.23	0.54	7.94	1.45	7.41	9.25
1S-JAG2	1.03	2.06	2.80	0.99	3.94	1.07	9.56	2.03	9.78	11.33
1S-JAG3	1.02	2.20	2.98	1.17	4.53	0.71	9.38	2.14	10.72	14.35
1S-SSA1	0.66	0.21	1.93	1.10	4.57	0.33	6.59	1.62	9.34	10.79
1S-SSA2	0.80	0.25	2.48	1.25	4.76	0.47	7.86	1.83	11.63	14.54
1S-SSA3	0.86	0.23	2.64	1.10	4.64	0.29	8.64	1.58	9.82	9.35
1S-VIT1	0.64	0.40	1.28	1.07	4.72	0.67	1.63	3.33	11.50	15.85
1S-VIT2	0.55	0.29	1.11	0.86	4.11	0.49	1.66	2.51	7.30	10.47
1S-VIT3	0.61	0.33	1.10	0.96	4.37	0.52	1.77	2.72	7.72	12.36
2S-SET1	1.31	0.33	5.33	1.19	4.58	0.72	14.32	1.99	9.60	17.71
2S-SET2	1.28	0.28	4.65	0.90	3.99	0.41	13.87	1.62	6.47	11.99
2S-SET3	1.16	0.30	4.27	1.05	4.06	0.59	12.08	1.97	8.72	16.05
2S-ACJ1	0.62	0.24	2.96	1.39	5.11	0.53	4.45	2.40	9.59	19.77

Table 2 (continued)

Sample	Ca[a]	Mg[a]	Na[a]	P[a]	K[a]	Cu[b]	Sr[b]	Mn[b]	Fe[b]	Zn[b]
2S-ACJ2	0.50	0.17	2.14	1.02	4.11	0.37	3.21	2.05	7.37	13.15
2S-ACJ3	0.41	0.14	1.51	0.83	3.50	0.24	2.90	1.55	6.29	11.65
2S-RE 1	0.77	0.28	5.99	1.06	3.97	0.45	7.45	2.91	7.28	14.87
2S-RE2	0.57	0.21	4.64	0.84	3.07	0.37	5.54	2.48	6.37	9.72
2S-RE3	0.84	0.26	6.75	1.01	4.02	0.41	8.22	2.96	6.99	15.24
2S-NAT1	0.81	0.40	4.82	1.31	4.72	0.53	5.38	3.31	10.44	22.75
2S-NAT2	0.97	0.37	5.27	1.12	4.56	0.38	6.63	3.03	7.37	17.66
2S-NAT3	0.78	0.36	4.92	1.26	4.63	0.56	5.09	3.20	10.19	20.70

[a] In milligrams per gram

[b] In micrograms per gram

used to determine the accuracy of the methods used in this paper. Digestion of this material was performed using the same decomposition procedure for the cabbage samples. The results were in agreement with the certified values, as can be seen in Table 1.

Results and Discussion

Determination of Chemical Elements in Chinese Cabbage Samples

The concentrations of calcium, magnesium, sodium, phosphorus, potassium, copper, strontium, manganese, iron, and zinc were determined in 57 samples of Chinese cabbage. Concentrations of these macro- and micronutrients are expressed as milligrams or micrograms of analyte per gram of sample, respectively, and are shown in Table 2.

Data Evaluation Employing Principal Component Analysis

The results of the determination of the elements in the 57 samples analyzed were evaluated using PCA. A data matrix was constructed using the elements as columns and the Chinese cabbage samples as rows (Table 2). The evaluation was performed on auto-scaled data because of different orders of magnitude in element concentrations. The loadings of the original variables on the first four principal components and the variances explained by each component are given in Table 3.

The first two principal components were chosen for modeling the data because they describe almost 54% of the total variance. Phosphorus, potassium, copper, iron, and manganese are the dominant variables for the first principal component (PC1) and represent 36% of the total variance. These five elements contribute to the major variability presented in the samples, and they are positively correlated. The second principal component (PC2) accounts for 18% of the total variance and includes strontium, calcium, sodium, and magnesium as the dominant variables. The score plot of the first two components is shown in Fig. 1.

Figure 1 shows no systematic separation between the varieties analyzed. Samples with high concentrations of phosphorus, copper, potassium, iron, and manganese had low scores for PC1 because the loadings for these elements are negative. This way, samples 2A-MC11, 2A-MC12, 2A-MC23, 2A-JAG2, and 1A-MR2 had high concentrations of the five elements. Sample 1A-MAR2 had the highest concentration of phosphorus and potassium, and 2A-JAG2 had the highest concentration of manganese. Samples with higher scores on PC1 had the smallest concentrations of these five elements. Sample 2S-ACJ3 had the lowest concentration of phosphorous and iron as well as low concentrations of potassium, copper, and manganese. Samples with lower scores on PC2 (2-SET1, 2-SET2, and 2-SET3) had higher concentrations of the elements

Table 3 Loadings of the variables for the first four principle components

Variable	PC1	PC2	PC3	PC4
Calcium	0.4323	−0.5983	−0.1464	−0.3097
Magnesium	−0.3073	−0.4993	0.5513	−0.3492
Sodium	−0.3540	−0.5495	−0.3327	0.5520
Phosphorous	−0.9286	0.1233	−0.1633	−0.0769
Potassium	−0.8205	0.2657	−0.1655	−0.2251
Copper	−0.8054	0.0927	0.1935	0.1442
Strontium	0.0860	−0.8474	−0.2713	−0.0016
Manganese	−0.6337	0.0658	0.3404	0.5278
Iron	−0.7064	0.0260	0.1501	−0.1658
Zinc	−0.2558	0.2600	−0.7892	−0.1240
Total variance (%)	35.64	17.94	13.62	9.21
Cumulative variance (%)	35.64	53.58	67.21	76.42

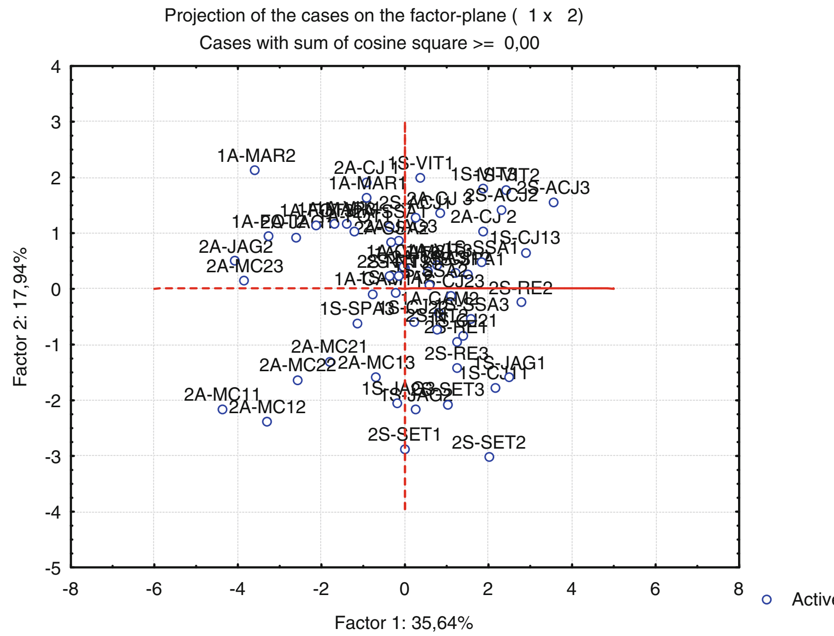

Fig. 1 Plot of PC1 versus PC2 for the 57 Chinese cabbage samples

strontium, calcium, sodium, and magnesium, considering that all these elements had negative loadings on PC2, Table 3. Sample 2-SET1 had the highest concentration for strontium. On the other hand, samples 1S-VIT1, 1S-VIT2, and 1S-VIT3, which corresponded to the lowest concentrations of strontium, had higher scores on PC2 and had low concentrations for these four elements. The third principal component (PC3) presented 14% of the total variance, where zinc, magnesium, and sodium were the dominant variables. They were, however, negatively correlated because zinc and sodium had negative loadings and magnesium showed a positive loading. Figure 2 depicts the score graph for the first and third PCs. An evaluation of this figure reveals that some samples were separated. Sample 1A-VIT1 had a low score on PC3; however, it had the highest concentration of zinc. Sample 2A-MC13 had a high concentration of magnesium and the lowest concentration of zinc.

The fourth principal component (PC4) contained 9% of the total variance consisting of the dominant variables of sodium and manganese, which were positively correlated.

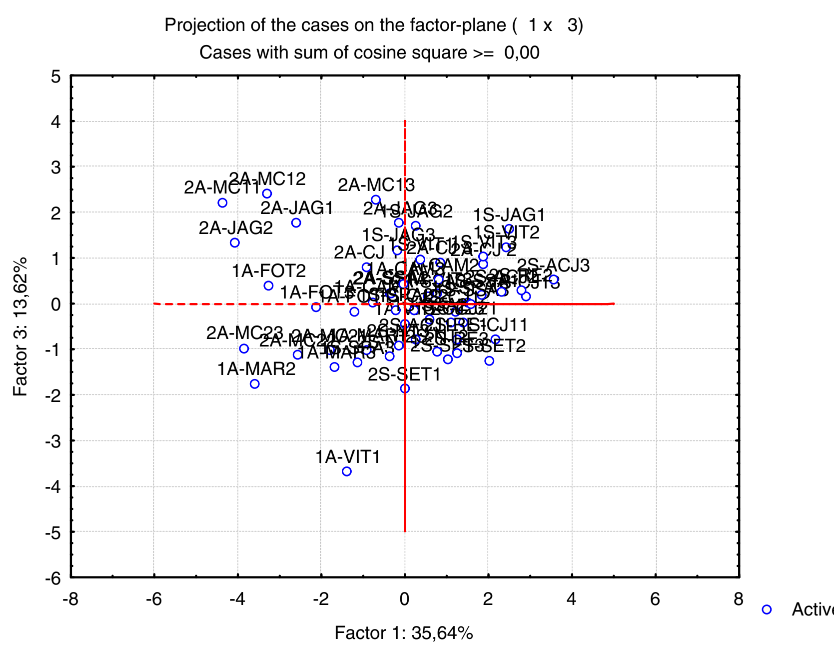

Fig. 2 Plot of PC1 versus PC3 for the 57 Chinese cabbage samples

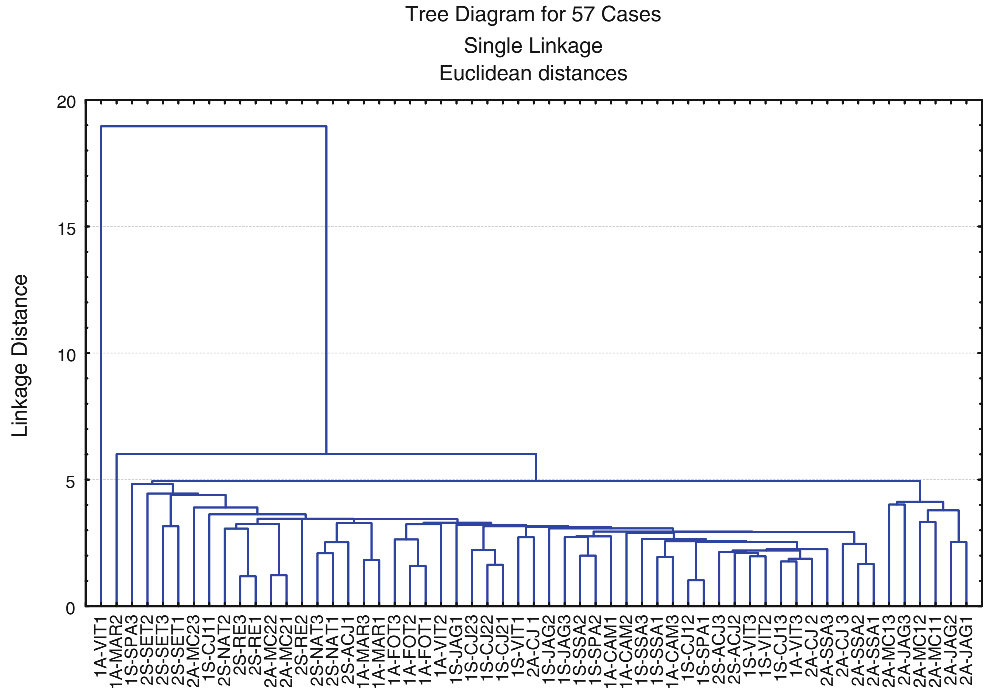

Fig. 3 Dendrogram for Chinese cabbage samples showing single linkage with Euclidean distances

Evaluation of Data Using Hierarchical Cluster Analysis

HCA was applied to the auto-scaled data using the single linkage method with Euclidean distances to calculate sample interpoint distances and similarities. The dendrogram obtained is shows in Fig. 3.

Some results found by PCA were also achieved using HCA. Sample 1A-VIT was found to be very separated on the graph compared to other samples using the method of HCA. Using PCA, the sample was found to have the highest concentration of zinc. Samples collected in Maceió City (2A-MC11 and 2A-MC12) and analyzed by PCA showed values in close proximity (Fig. 3) and formed a small group. Samples 2A-JAG2, 2A-JAG1, 2A-MC11, 2A-MC12, 2A-JAG3, and 2A-MC13 can also be observed in Fig. 3. By PCA, some of these samples had low scores for PC1 because they have high concentrations of phosphorous, copper, potassium, iron, and manganese, which are the dominant variables for PC1.

Determination of the Mineral Composition of Cabbage

The results obtained by PCA and HCA demonstrated that there was no systematic difference in the mineral composition of the Chinese cabbage samples collected in 13 Brazilian cities. The average concentrations of the elements were calculated using the data obtained for the 57 samples analyzed. The average concentrations and ranges of concentration (as gram of fresh weight) were found to be the following, respectively: 3.44 and 1.10–6.75 mg g^{-1} for sodium, 5.09 and 3.07–9.15 mg g^{-1} for potassium, 1.25 and 0.75–2.00 mg g^{-1} for phosphorous, 0.85 and 0.25–1.54 mg g^{-1} for calcium, 0.49 and 0.14–2.41 mg g^{-1} for magnesium, 2.79 and 0.95–5.89 μg g^{-1} for manganese, 9.50 and 5.53–14.61 μg g^{-1} for iron, 0.74 and 0.16–2.21 μg g^{-1} for copper, 14.28 and 4.65–41.95 μg g^{-1} for zinc, and 6.44 and 1.63–14.32 μg g^{-1} for strontium (Table 4).

Conclusions

The PCA technique demonstrated that phosphorus, potassium, copper, iron, and manganese are the elements that contribute to the major variability presented in the Chinese cabbage samples analyzed.

Table 4 Concentrations of chemical elements in Chinese cabbage samples

Element	Average concentration	Concentration range
Calcium (mg g^{-1})	0.85	0.25–1.54
Magnesium (mg g^{-1})	0.49	0.14–2.41
Sodium (mg g^{-1})	3.44	1.10–6.75
Phosphorous (mg g^{-1})	1.25	0.75–2.00
Potassium (mg g^{-1})	5.09	3.07–9.15
Copper (μg g^{-1})	0.74	0.16–2.21
Strontium (μg g^{-1})	6.44	1.63–14.32
Manganese (μg g^{-1})	2.79	0.95–5.89
Iron (μg g^{-1})	9.50	5.53–14.61
Zinc (μg g^{-1})	14.28	4.65–41.95

Results of PCA and HCA on the data of the ten elements demonstrated that the variation of the mineral composition for the 57 Chinese cabbage samples analyzed was completely random.

The concentrations of the macro- and micronutrients found in the Chinese cabbage samples analyzed demonstrate that the vegetable can be used as a nutritional supplement.

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References

Aberoumand A (2009) Food Anal Methods 2:204

Bantan-Polak T, Mitrovic B, Milacic P (2005) Anal Chim Acta 540:83

Bhat R, Kiran K, Arun KAB, Karim AA (2010) Food Anal Methods 3:181

Choi MK, Kang MH, Kim MH (2009) Biol Trace Elem Res 128:104

Fadigas JC, dos Santos AMP, de Jesus RM, Lima DC, Fragoso WD, David JM, Ferreira SLC (2010) Microchem J 96:352

Fasciotti M, Netto ADP (2010) Talanta 81:1116

Feliciano RP, Bravo MN, Pires MM, Serra AT, Duarte CM, Boas LV, Bronze MR (2009) Food Anal Methods 2:149

Kawashima LM, Soares LMV (2003) J Food Compos Anal 16:605

Kelly SD, Bateman AS (2010) Food Chem 119:738

Korhonova M, Hron K, Klimcikova D, Mueller L, Bednar P, Bartak P (2009) Talanta 80:710

Lima DC, dos Santos AMP, Araujo RGO, Scarminio IS, Bruns RE, Ferreira SLC (2010) Microchem J 95:222

Mendil D, Celik F, Tuzen M, Soylak M (2009) J Hazard Mater 166:1344

Nascimento IR, Jesus RM, dos Santos WNL, Santos AS, Fragoso WD, Reis PS (2010) Microchem J 96:37

Pasha Q, Malik SA, Shaheen N, Shah MH (2010) Biol Trace Elem Res 134:160

Pereira AC, Reis MC, Saraiva PM, Marques JC (2010) Anal Chim Acta 659:93

Prasad S, Chetty AA (2008) Food Chem 106:772

Roy MK, Takenaka M, Isobe S, Sushida T (2007) Food Chem 103:106

Salahinejad M, Aflaki F (2010) Biol Trace Elem Res 134:109

Sharaf MA, Illman DL, Kowalski BR (1986) Chemometrics. John Wiley and Sons, New York

Soylak M, Turkoglu O (1999) J Trace Microprobe Tech 17:209

Spiric A, Trbovic D, Vranic D, Djinovic J (2010) Anal Chim Acta 672:66

Yuan X, Shi J, Yang Y, Luan J, Gao J, Wang Y (2010) Biol Trace Elem Res 135:304