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Determining the Geographic Origin of Potatoes Using Mineral and Trace Element Content

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To characterize potatoes according to their geographic origin and variety, 10 mineral and trace elements (Mg, Cr, Mn, Fe, Ni, Cu, Zn, Sr, Cd, and Ba) were determined in Italian potato samples. The data collected were successively elaborated using statistical techniques, namely, linear discriminant analysis (LDA). LDA was able to classify and discriminate the potatoes from Fucino both from those of other areas of Italy and from those of the four provinces of Abruzzo. A net separation between the Fucino potatoes and those of the other areas of Abruzzo was observed. LDA discriminated also the three potato varieties cultivated in the Fucino basin. The presence of these 10 mineral and trace elements was a good means for establishing the geographical place of origin of Fucino potatoes.

KEYWORDS: Potatoes; geographic origin; mineral and trace element; multivariate statistical analysis; linear discriminant analysis; chemical composition

INTRODUCTION

Research related to the determination of the geographical origin of commodities, particularly foodstuffs, has represented an important line of study in commodity science for a long time. The promulgation of national and international laws regulating the identification of product origins is an indication of the growing interest in this field. For example, in the European Community there are some legislative regulations regarding the protection of alimentary products or the typical geographical indication or the control of the origin of wines.

The determination and certification product origin represent a form of protection for the consumer and, at the same time, a means of maintaining prestige and credibility for the food industry. Many analytical methodologies have been employed to determine the place of origin of commodities. The dosing of trace element content has been shown to be one of the most effective of these methodologies. This is because the diffusion of trace elements in the food chain constitutes a reliable marker of environmental conditions and because mineral elements do not suffer alterations as do, for example, amino acids and vitamins, which are also used to determine origin.

It has been observed that the mineral composition of soils, apart from considerations of the level of bioavailability and of permeability through the roots, influences the entire food chain and, consequently, vegetable and animal foodstuff composition. For this reason some research has been carried out to identify the place of origin of some common foodstuffs on the basis of trace element content. Most of these studies have related to fish species, fresh- and seawater (*1−8*), and vegetable products (grapes and wines) (*9−16*).

Most papers that deal with the determination of the origin of foods using trace element analysis regard processed food, especially wine, but cheeses (*17−21*), fruit juices (*22−24*), tea (*25*), cacao, and coffee have also been studied. Papers regarding unprocessed foods are scarce and usually deal with fish, potatoes (*26−29*), and whole-meal rice (*30*).

In Abruzzo, there is a particular area in which potatoes have traditionally been cultivated. This special cultivation area is in an intermountain valley, the Fucino basin, where there used to be a big lake that was drained during the 19th century. The geomorphic features of this terrain are erosion and terracing brought about by deposits of lake and river sediments. This valley is located near Avezzano, in the province of L’Aquila (**Figure 1**). Because potatoes are a traditional cultivation and a distinctive product of the regional economy, it was thought that it would be of interest to find a method useful to identify the geographic origin by using trace element content to protect the products’ distinctive identity.

MATERIALS AND METHODS

Samples. Thirty potato samples, each made up of 3 potatoes taken from sacks of 5 kg containing about 20 potatoes from the Fucino basin and belonging to three different varieties, ‘Agata’, ‘Sirco’, and ‘Agria’, were collected during the spring of 2005 (10 samples for each variety). Moreover, an additional 30 potato samples from Pescara, Chieti, and Teramo (the remaining provinces of Abruzzo) and from other Italian regions (Lazio, Molise, Puglia, Emilia Romagna, and Veneto) were also collected during the same period. Fucino potatoes come from areas that are used specifically for the cultivation of those particular varieties of potatoes, whereas the samples from other areas under consideration were acquired from farms that do not indicate variety, but only the place of origin of their product. Given the presumable homogeneity of the potatoes in each sack, the number of samples is sufficient to be representative of the sampled universe.

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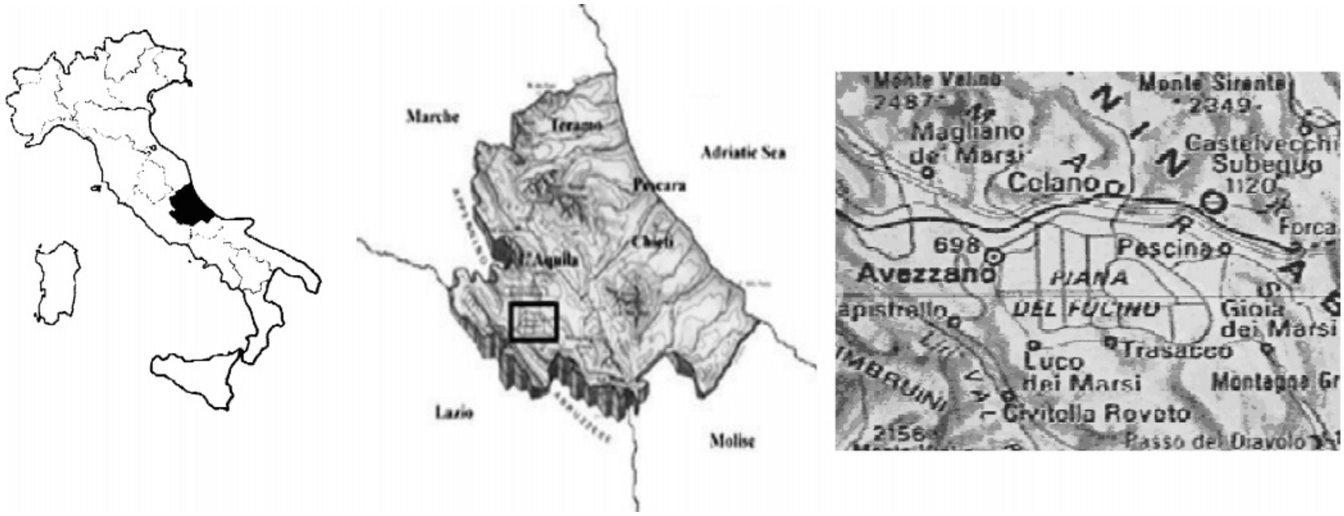

Figure 1. Italy, Abruzzo, and Fucino basin maps.

The samples were washed in running water and then peeled, removing about 2 mm of surface. The center cross section of potatoes was used and homogenized, and about 1 g of homogenized material, dried at 105 °C, was analyzed. In the present research, of the 20 elements dosed, 10 elements (Mg, Cr, Mn, Fe, Ni, Cu, Zn, Sr, Cd, and Ba) are sufficient to discriminate the samples of potatoes with 100% of the cases correctly classified.

Apparatus. An inductively coupled plasma mass spectometer (ICP-MS), Agilent model 7500A (Santa Clara, CA), was used. The microwave apparatus was a Milestone ETHOS 900 Labstation (Shelton, CT).

Reagents. Internal standard solution mix (Sc45, Ge72, In115, Bi209, HNO_3 5%) was obtained from Agilent. Multielement solution with nitric acid (2%) was obtained from 65% nitric acid and 18 MΩ water (Milli-Q system) for external calibration. HNO_3 65% Suprapur and H_2O_2 30% Suprapur were from Merck.

Analytical Procedure. About 1 g of dry material was subjected to an ambient temperature digestion using 7 mL of nitric acid 65% for 24 h. It was then subjected to mineralization using a microwave oven as follows: step 1, 5 min at 300 W; step 2, cooling followed by the addition of 1 mL of nitric acid, which was followed by 7 min at 300 W plus 4 min at 350 W; step 3, cooling followed by the addition of 0.5 mL of H_2O_2, which was followed by 7 min at 250 W plus 4 min at 400 W plus 4 min at 600 W. Digestion was confirmed to be complete when no nitrous oxide gases were evolved. After mineralization, the sample was recovered with deionized water and brought to a volume of 10 mL.

The sample was analyzed with an ICP-MS, using the following operating conditions: Rf power, 1250 W; sample depth, 6 mm; plasma gas flow rate, 14.90 L/min; carrier gas, 1.18 L/min; sample uptake rate by peristaltic pump, 0.1 rps. Simultaneous determination of Cr, Ni, Sr, Cd, and Ba was attained by monitoring ^{53}Cr, ^{60}Ni, ^{88}Sr, ^{111}Cd, and ^{137}Ba isotopes. Data were obtained from three experimental replicates and five instrumental replicates of diluted (1/10) sample solutions. Mn, Cu, and Zn were determined by monitoring ^{55}Mn, ^{63}Cu, and ^{67}Zn. Data were obtained from three experimental replicates and five instrumental replicates of diluted (1/20) sample solutions. Mg and Fe were determined monitoring ^{24}Mg and ^{57}Fe. Data were obtained from three experimental replicates (three separate times 1 g of material was taken from three potatoes from each of the sacks and then broken up and diluted) and five instrumental replicates of diluted (1/40) sample solutions. The total content of these elements was obtained by natural isotope abundance.

Recovery and standard deviations were performed with the following three different standard reference materials: corn bran std NIST; carrot powder std ARG, and edible fungus std NFA; confidence level was 98% (**Table 1**).

Statistical Analysis. Linear discriminant analysis (LDA) was applied to the separation of the analyzed potato samples according to their place of origin and variety. As the group membership of each sample was already known, LDA was applied to this variable set to evaluate the sample differentiation and classification of the data expressed as discriminant scores. LDA has been extensively discussed by several authors (*31*−*33*).

Table 1. Recovery, Actual Value, and Standard Deviation of Three Different Standard Reference Materials Used during the Study

element	% recovery corn bran std NIST	carrot powder std ARG	edible fungus std NFA	actual value[a]	% SD[a]
Mg	106.7	98.2	109.6	1142.3	15.8
Cr	103.7	103.4	105.4	0.318	4.2
Mn	86.1	99.6	87.4	3.03	16.3
Fe	93.1	90.5	95.9	38.62	31.7
Ni	112.6	109.2	102.4	0.12	8.9
Cu	114.8	112.7	95.9	2.61	4.8
Zn	105.0	108.2	105.4	9.11	4.0
Sr	107.2	111.1	107.1	4.10	35.0
Cd	115.5	107.7	108.9	0.04	8.8
Ba	97.2	95.1	94.2	1.31	33.3

[a] The results obtained from 10 observations, as far as intralaboratory repeatability is concerned, are expressed as mean ($\mu g\ g^{-1}$) and % standard deviation (SD). Corn bran std NIST % SD ranged from 5.2 to 21%; carrot powder std ARG % SD ranged from 3.5 to 12%; edible fungus std NFA % SD ranged from 1 to 6%.

RESULTS AND DISCUSSION

The values regarding the content of mineral and trace elements in potatoes from the Fucino basin (30 samples) are reported in **Table 2**. In **Table 3** the values related to the remaining potato samples from other places in Abruzzo and other Italian regions (30 samples) are presented. All data obtained were analyzed statistically using multivariate statistical approaches, in particular LDA. This methodology was applied to separate the 60 potato samples on the basis of the presence of 10 mineral and trace elements, using different variables, such as place of origin and variety, as class identity. The aim of this procedure was to evaluate sample differentiation and classification of data expressed as discriminant scores.

Therefore, depending on the number of groups, one or two discriminant functions were extracted. To determine the number of linear discriminant functions to retain, Bartlett's classical test was applied:

$$b = -[N - (p + g)/2 - 1] \ln \Lambda$$

Table 2. Data Matrix of Potatoes from the Fucino Basin ($n = 30$)

sample	concentration, μg g^{-1} (dry matter)									
	Cr	Ni	Sr	Cd	Ba	Mn	Cu	Zn	Mg	Fe
C1 (Agata)	0.048	0.603	0.517	0.110	3.276	6.249	7.687	18.259	1447.66	21.46
*C*2 (Sirco)	0.075	0.640	0.473	0.089	0.485	5.700	10.025	17.010	1311.85	13.66
C3 (Agria)	0.050	0.704	0.668	0.082	3.048	4.081	7.382	13.166	1406.90	16.70
C4 (Sirco)	0.054	0.654	0.603	0.158	3.059	5.237	8.984	16.294	1335.50	16.50
C5 (Agria)	0.050	0.393	0.786	0.084	3.077	6.719	12.149	21.087	1660.80	18.40
C6 (Sirco)	0.036	0.325	0.576	0.044	3.439	6.647	11.379	19.464	1391.20	17.60
C7 (Sirco)	0.629	0.433	0.752	0.089	3.556	6.017	8.802	14.521	1423.62	16.04
C8 (Agria)	0.035	0.396	0.822	0.098	4.620	3.839	9.535	15.904	1132.16	12.18
C9 (Agria)	0.032	0.606	0.773	0.041	5.022	4.647	16.127	25.055	722.55	46.75
C10 (Sirco)	0.036	0.580	0.758	0.097	3.071	7.060	10.860	22.414	766.85	34.45
C11 (Sirco)	0.064	0.125	0.638	0.094	2.522	5.696	9.117	0.019	1084.27	13.51
C12 (Agata)	0.084	0.286	0.368	0.112	0.316	6.752	9.010	0.019	1304.03	20.33
C13 (Sirco)	0.090	0.232	0.408	0.110	2.606	5.990	10.075	0.020	1173.10	18.19
C14 (Sirco)	0.047	0.186	0.518	0.075	2.994	5.590	7.906	0.018	1105.44	14.60
C15 (Agata)	0.053	0.331	0.695	0.060	0.449	6.324	11.198	0.022	1375.82	18.68
C16 (Agata)	0.031	1.216	0.469	0.109	3.508	6.354	8.969	0.027	1425.70	21.15
C17 (Agata)	0.073	0.279	0.274	0.070	2.205	4.534	6.604	0.017	1152.76	21.27
C18 (Agata)	0.015	0.198	0.239	0.070	3.029	5.835	7.082	0.017	1254.73	17.49
C19 (Sirco)	0.022	0.254	0.219	0.056	1.809	6.640	8.129	0.014	1274.23	15.81
C20 (Agria)	0.023	0.946	0.566	0.050	2.960	3.026	9.544	0.017	1129.00	17.12
C21 (Agata)	0.034	0.360	0.611	0.056	0.979	7.297	8.636	22.323	1352.93	24.06
C22 (Agria)	0.039	0.628	0.560	0.097	3.521	4.022	10.020	22.023	1027.22	18.81
C23 (Agata)	0.041	0.500	0.380	0.054	0.290	6.764	8.191	19.793	1239.90	19.90
C24 (Agria)	0.023	0.445	0.765	0.062	0.802	4.502	10.444	20.156	1217.01	19.31
C25 (Sirco)	0.017	0.611	0.306	0.146	1.753	4.949	6.228	17.271	962.40	12.30
C26 (Agria)	0.040	0.308	0.424	0.057	0.583	5.729	9.345	20.648	1208.00	22.77
C27 (Agria)	0.049	0.341	0.405	0.065	0.626	4.713	8.273	16.145	1304.77	19.21
C28 (Agria)	0.048	0.669	0.494	0.089	0.604	4.798	7.884	17.748	1094.84	18.71
C29 (Agata)	0.051	0.387	0.280	0.050	0.308	4.885	9.259	16.042	1168.00	18.40
C30 (Agata)	0.085	0.685	0.434	0.080	3.092	6.606	8.226	17.296	1217.30	22.20
minimum	0.015	0.125	0.219	0.041	0.290	3.026	6.228	0.014	722.55	12.18
maximum	0.629	1.216	0.822	0.158	5.022	7.297	16.127	25.055	1660.80	46.75
mean	0.066	0.477	0.526	0.082	2.254	5.573	9.236	12.427	1222.35	19.59
median	0.047	0.415	0.517	0.081	2.783	5.714	8.997	16.219	1228.60	18.54
variance	0.012	0.057	0.031	0.001	1.927	1.183	3.645	85.663	38124.70	44.01

N stands for the number of observations, p for the number of variables, g for the number of groups, and Λ the ratio of the within-group sum of squares to the total sum of squares. Wilks' Λ value provides information pertaining to how much of the total variability is due to the differences between the group means or to the within-group variability. The value of Λ can range between 0 and 1: $\Lambda = 1$ when the two group means are equal, whereas $\Lambda = 0$ if they differ (*34*).

Once a set of q variables has been selected, the classification rule (also known as Fisher's linear discriminant functions) can be computed using

$$b_{ij} = (n - g)\sum_{l=1}^{q} w^{*}_{il}\overline{X_{lj}}$$

$$i = 1, 2, ..., q; j = 1, 2, ..., g$$

for the coefficient and

$$a_j = \log p_j - \frac{1}{2}\sum_{i=1}^{q} b_{ij}\overline{X_{ij}}$$

$$j = 1, 2, ..., q$$

for the constant, where p_j is the prior probability of group j.

A significant Wilks Λ value was obtained when the potato samples were classified as a function of the place of origin, comparing potato samples from the Fucino basin and potatoes from other areas of Abruzzo. In this case, one discriminant function was estimated, because the number of groups in this sample was 2, and $2 - 1$ is the maximum allowable number of eigenvalues for the matrix $W^{-1}B$. The first discriminant eigenvalue (3.111) had a Wilks Λ value of close to zero (0.243).

The distribution of data expressed as discriminant scores along the first eigenvector is presented in **Figure 2**. In this representation of all data, the two sample classes, corresponding to potato samples from the Fucino basin (G1) and other areas of Abruzzo (G2), respectively, were clearly distinct.

On the basis of the values for the two linear discriminant functions for each sample, the group membership could be predicted using a classification rule. **Table 4** summarizes the results of the classification for the potato samples, where the actual and predicted group membership and, on the diagonal, the number of the samples classified correctly, are shown. In this case, all potato samples were correctly assigned to the group they belong to. Furthermore, the overall classification success was 100%.

According to Wilks Λ value another distribution was quite significant. In fact, if the whole data set is analyzed as a function of place of origin with a comparison between samples from the Fucino basin and others from all over Italy, the results obtained are the following: One discriminant function was estimated, because the number of groups in this sample was 2, and $2 - 1$ is the maximum allowable number of eigenvalues for the matrix $W^{-1}B$. The first discriminant eigenvalue (2.277) had a Wilks Λ value of close to zero (0.305).

The distribution of data expressed as discriminant scores along the first eigenvector is presented in **Figure 3**. In this representation of all data, the two sample classes, corresponding to potato

Table 3. Data Matrix of Potatoes from Other Places in Abruzzo and Other Italian Regions ($n = 30$)

sample	concentration, μg g^{-1} (dry matter)									
	Cr	Ni	Sr	Cd	Ba	Mn	Cu	Zn	Mg	Fe
C31	0.040	0.545	0.762	0.054	0.891	7.538	7.743	0.015	1127.81	22.37
C32	0.076	0.298	0.593	0.052	0.492	6.725	5.289	0.010	1130.98	27.63
C33	0.055	0.231	1.828	0.023	3.632	8.127	6.507	0.012	1249.28	15.13
C34	0.041	0.312	0.903	0.041	0.508	9.131	6.982	0.011	1336.40	14.34
C35	0.033	0.380	0.834	0.110	0.484	6.948	9.010	0.014	1149.10	18.55
C36	0.043	0.453	0.568	0.064	0.623	9.003	9.173	0.019	1042.27	18.90
C37	0.139	0.322	0.645	0.020	0.396	8.764	8.767	0.015	1249.48	14.78
C38	0.164	0.296	0.971	0.017	0.560	7.162	9.040	0.014	1123.35	13.37
C39	0.036	0.199	1.056	0.045	0.547	6.755	6.639	0.018	960.00	17.93
C40	0.036	0.398	1.938	0.021	0.448	4.956	10.741	0.027	1232.55	21.01
C41	0.346	0.036	1.237	0.083	0.632	6.058	14.493	23.338	773.59	30.89
C42	0.344	0.033	0.478	0.061	0.447	7.859	14.262	24.680	962.30	32.80
C43	0.325	0.028	0.397	0.223	0.683	7.946	5.326	17.356	919.60	22.50
C44	0.317	0.035	1.151	0.028	0.940	7.140	9.544	19.248	694.19	19.11
C45	0.318	0.047	0.740	0.023	0.712	7.282	13.235	20.227	865.90	19.30
C46	0.286	0.026	4.010	0.171	2.182	8.541	11.980	26.153	952.70	43.20
C47	0.281	0.039	1.476	0.043	0.359	7.661	12.083	23.353	1323.50	38.60
C48	0.277	0.160	8.326	0.030	7.859	8.620	16.713	25.093	1438.17	45.05
C49	0.272	0.129	8.346	0.024	8.155	8.836	16.637	25.153	1436.00	32.10
C50	0.238	0.046	0.878	0.029	0.337	4.093	13.636	25.529	717.75	14.85
C51	0.059	0.791	1.362	0.133	0.528	4.755	7.401	20.922	1064.28	19.99
C52	0.058	0.394	0.900	0.061	0.481	4.990	7.009	15.040	913.50	14.50
C53	0.045	0.352	0.604	0.060	0.432	6.322	7.195	18.822	1041.18	14.85
C54	0.047	0.889	0.237	0.335	0.211	6.039	5.595	12.870	1135.43	22.83
C55	0.089	0.270	0.239	0.098	0.290	7.929	4.775	13.610	1084.37	12.74
C56	0.027	0.057	0.164	0.050	0.082	5.840	2.842	14.943	998.22	19.60
C57	0.063	0.129	0.210	0.104	0.147	5.266	3.892	17.548	898.07	17.74
C58	0.053	0.138	0.278	0.062	0.245	4.838	2.609	9.116	792.90	40.60
C59	0.079	0.193	0.470	0.074	2.137	4.757	6.166	14.098	1115.23	16.04
C60	0.075	0.164	0.630	0.390	1.308	4.269	6.839	13.790	966.14	14.95
minimum	0.027	0.026	0.164	0.017	0.082	4.093	2.609	0.010	694.19	12.74
maximum	0.346	0.889	8.346	0.390	8.155	9.131	16.713	26.153	1438.17	45.05
mean	0.142	0.246	1.408	0.084	1.225	6.805	8.737	12.701	1056.47	22.54
median	0.076	0.196	0.798	0.057	0.518	7.044	7.572	14.520	1053.28	19.21
variance	0.014	0.048	4.089	0.008	3.931	2.384	15.046	100.363	38484.07	88.57

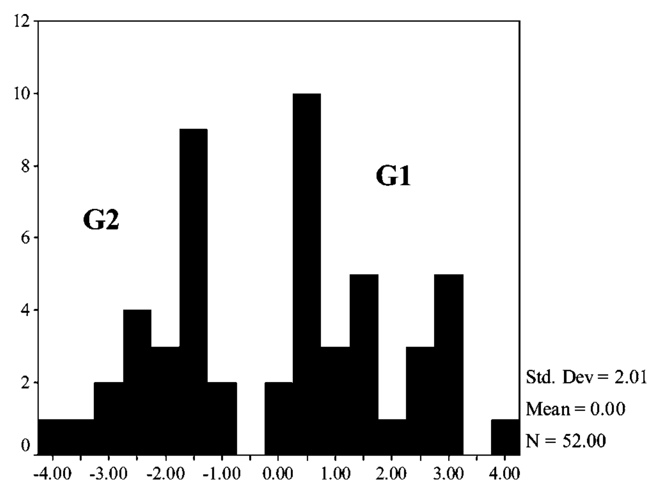

Figure 2. Distribution of data, related to potato samples belonging to the Fucino basin and other areas of Abruzzo, expressed as discriminant scores along the first eigenvector (G1, potatoes from the Fucino basin; G2, potatoes from other places in Abruzzo).

samples from the Fucino basin (G1) and from other areas of Italy (G2), respectively, were quite distinct.

On the basis of the values for the two linear discriminant functions for each sample, the group membership could be predicted using a classification rule. **Table 5** summarizes the results of the classification for the potato samples, where the actual and predicted group membership and, on the diagonal, the number of the samples classified correctly, are shown. In this case, all potato samples were correctly assigned to the group they belong to, with one exception regarding a sample from one of the other areas of Italy. The overall classification success was 98.3%.

Table 4. Classification Table for Two Groups of Potato Samples: G1, Potatoes from the Fucino Basin; G2, Potatoes from Other Places in Abruzzo

actual group	predicted group		
	G1	G2	total
G1	30	0	30
G2	0	22	22
total	30	22	52
accuracy of prediction, %	100.0	100.0	

The multivariate statistical analysis was also applied to potato samples from the Fucino basin in comparison with samples from the three other provinces of Abruzzo (52 samples). Again, two discriminant functions were estimated. The first discriminant eigenvalue (3.907) had a Wilks Λ value of close to zero (0.058), whereas the second eigenvalue (1.380) had a Λ value of 0.284. The first eigenvalue alone accounted for 67.8% of the total variability.

The distribution of data expressed as discriminant scores along the first two eigenvectors is presented in **Figure 4**. The four sample classes, corresponding to different provinces of Abruzzo, were clearly distinct, as is shown by the centroid co-ordinates. The first sample class, corresponding to the Fucino basin potato

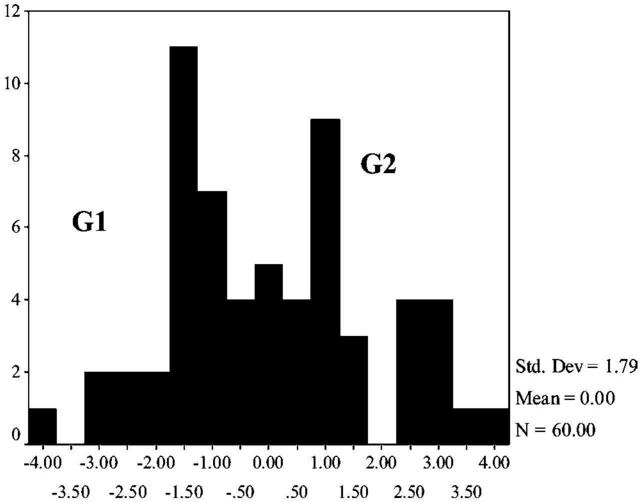

Figure 3. Distribution of data, related to potato samples belonging to the Fucino basin and other areas of Italy, expressed as discriminant scores along the first eigenvector (G1, potatoes from the Fucino basin; G2, potatoes from other areas of Italy).

Table 5. Classification Table for Two Groups of Potato Samples: G1, Potatoes from the Fucino Basin; G2, Potatoes from Other Areas of Italy

	predicted group		
actual group	G1	G2	total
G1	30	0	30
G2	1	29	30
total	31	29	60
accuracy of prediction, %	100.0	96.7	

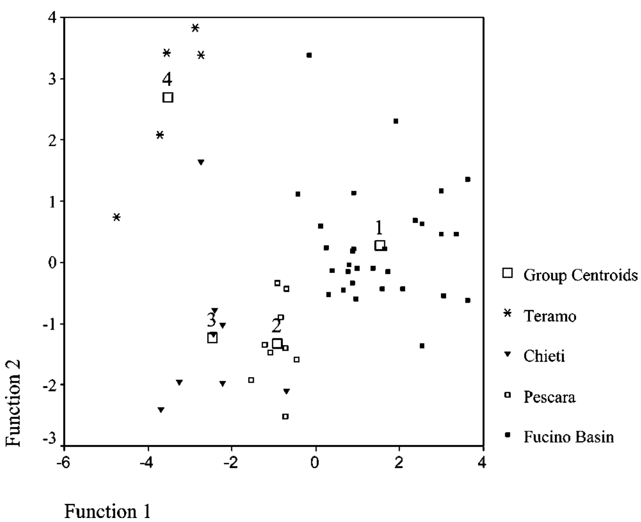

Figure 4. Distribution of data, related to potato samples from the four provinces of Abruzzo, expressed as discriminant scores along the two eigenvectors, as a function of place of origin.

samples, seemed to be well separated from the others, among which samples from Chieti and Pescara overlapped slightly.

Therefore, on the basis of the values for the two linear discriminant functions for each sample, the group membership could be predicted using a classification rule. **Table 6** summarizes the results of the classification for the potato samples, where the actual and predicted group membership and, on the diagonal, the number of the samples classified correctly, are shown. In this case, only potato samples from Teramo and Pescara were correctly assigned to the group they belong to,

Table 6. Classification Table for Four Groups of Potato Samples: G1, Potatoes from the Fucino Basin; G2, Potatoes from Pescara; G3, Potatoes from Chieti; G4, Potatoes from Teramo

	predicted group				
actual group	G1	G2	G3	G4	total
G1	28	1	0	1	30
G2	0	9	0	0	9
G3	0	1	6	1	8
G4	0	0	0	5	5
total	28	10	6	7	52
accuracy of prediction, %	93.3	100.0	75.0	100.0	

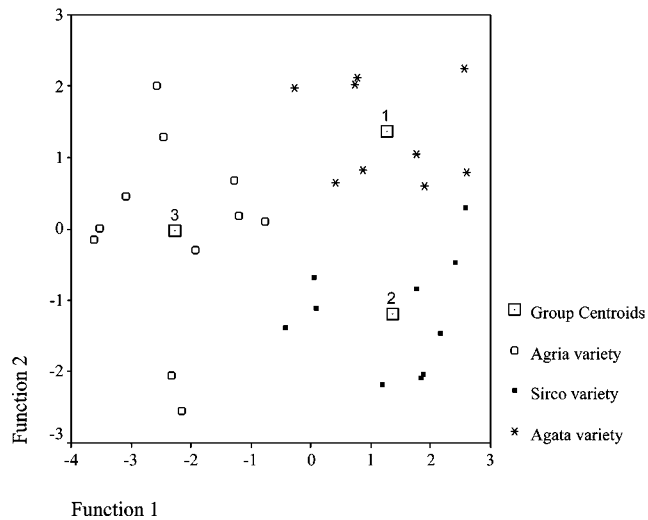

Figure 5. Distribution of data, related to potato samples corresponding to different varieties, expressed as discriminant scores along the two eigenvectors, as a function of variety.

whereas samples from the Fucino basin and Chieti had percentages of correctly classified cases equal to 93.3 and 75.0%, respectively. Furthermore, the overall classification success was 92.3%.

By limiting the scope of focus to the 30 potato samples from the Fucino basin it was possible to determine that trace element content is able to discriminate the three different varieties cultivated there.

Again, two discriminant functions were estimated. The first discriminant eigenvalue (3.306) had a Wilks Λ value of close to zero (0.108), whereas the second eigenvalue (1.147) had a Λ value of 0.466. The first eigenvalue alone accounted for 74.2% of the total variability.

The distribution of data expressed as discriminant scores along the first two eigenvectors is presented in **Figure 5**. The three sample classes, corresponding to different varieties, were clearly distinct, as is shown by centroid co-ordinates. The first and third sample classes, corresponding to the 'Agata' and 'Agria' varieties, seemed to be well separated from the other ('Sirco') with only one sample incorrectly classified. Therefore, on the basis of the values for the two linear discriminant functions for each sample, the group membership could be predicted using a classification rule. **Table 7** summarizes the results of the classification for the potato samples, where the actual and predicted group membership and, on the diagonal, the number of the samples classified correctly, are shown. The overall classification success was 96.7%.

In conclusion, the statistical analysis of data regarding the content of Cr, Ni, Sr, Cd, Ba, Mn, Cu, Zn, Mg, and Fe in potato samples puts in evidence the distinction both between the Fucino

Table 7. Classification Table for Three Groups of Potato Samples: G1, Potatoes of 'Agata' Variety; G2, Potatoes of 'Sirco' Variety; G3, Potatoes of 'Agria' Variety

	predicted group			
actual group	G1	G2	G3	total
G1	9	0	0	9
G2	1	9	0	10
G3	0	0	11	11
total	10	9	11	30
accuracy of prediction, %	100.0	90.0	100.0	

potatoes and those of other areas of Abruzzo (100%) and between Fucino potatoes and those of the remaining areas of Italy (98.3%). A clear distinction can also be seen when we compare the potatoes from the four provinces of Abruzzo that account for 92.3% of the correctly assigned cases. These results are consistent with a similar paper written about Idaho-labeled potatoes (*27*).

It is also interesting to note that the content of minerals and microelements is able to discriminate the three potato varieties cultivated in the Fucino basin with a percentage of correctly assigned cases equal to 96.7%. Therefore, it is possible to affirm that the content of mineral and trace elements is a good instrument for establishing the geographical place of origin of Fucino potatoes and also their variety.

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