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Analytical study of the mineral fraction of mustard seed and mustard sauces

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The mineral fraction of six mustards (whole seed or flour) and 40 mustard sauces has been determined by atomic absorption spectroscopy. Mineral macroelements (Na, K, Ca, Mg) and microelements (Cu, Fe, Mn, Zn) were studied in order to characterize these products in relation to their base seed: mustard. Potassium, calcium and magnesium were the major macroelements in mustard seeds, while higher levels of sodium were found in mustard sauces. By means of correlation and discriminant analysis, the samples have been grouped and classified. It is shown that all components of the mineral fraction are useful parameters for quality control analysis of mustard sauces. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

Mustards are the seeds of *Brassica nigra* (black mustard) and *Sinapis alba* (white mustard). Both kinds of mustard are important spices used for flavour and aroma. The whole seeds are used in pickles and in salads while the prepared mustard, which is a mixture of ground mustard with salt, vinegar, spices and other condiments, is used in sandwiches, frankfurters and gravies. Mustard flour finds a place in the preparation of meats, fish and sauces, and in medicine it is used as mustard plastus for giving relief in respiratory illnesses (Font Quer, 1995).

In this paper, the mineral fraction of mustard seeds and commercially prepared mustard sauces has been analysed in order to characterise these products in relation to their base seed—mustard—and to evaluate the participation of the seed and other components in the preparation of the sauces. By means of discriminant analysis and correlation analysis applied to the analytical results obtained, the samples have been grouped and classified.

MATERIALS AND METHODS

Samples

Mustard, seed or flour, mustard sauces with whole grain and mustard sauces were selected from the Spanish market. Except for one of the seed samples that was acquired in Sri Lanka, all the samples were manufactured or packaged in Spain and other countries of the European Community.

The samples were numbered with two figures, the first one corresponding to the group and the second to the number of sample.

1. Group 1: 34 mustard sauces (1.1–1.34)
2. Group 2: 6 mustards (seed, flour) (2.1–2.6)
3. Group 3: 6 mustard sauces with whole grain (3.1–3.6)

Methods

Mineral composition by atomic absorption spectroscopy was studied. Mineral macroelements (Na, K, Ca, Mg) and microelements (Cu, Fe, Mn, Zn) were determined. The samples were dry-ashed to eliminate the organic matter. They were then dissolved to give homogeneous acidic solutions (Torija-Isasa, 1981).

Statistical study

In order to have a better interpretation of the analytical results, a discriminant analysis was applied to the data obtained and computerized in the Statgraphic program (Lebart, 1985; STSC, 1986).

RESULTS AND DISCUSSION

All tables show the mean values of three analyses.

Potassium has been found to be the major macroelement in mustard seeds, while calcium and magnesium are present in a lower proportion (Pérez-Bueno, 1994). The results obtained for the seeds and flours analysed

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Table 1. Mustard sauces: macroelements composition (mg/100 g)

Sample	Na	K	Ca	Mg
1.1	1537	170	48.0	52.4
1.2	1253	130	78.6	39.4
1.3	535	60.8	82.6	51.3
1.4	1452	89.6	62.3	35.1
1.5	658	54.5	60.7	27.3
1.6	1141	140	94.7	271
1.7	2270	232	114	93.3
1.8	620	172	97.9	75.5
1.9	636	167	121	52.1
1.10	2114	224	66.1	107
1.11	1945	143	95.3	58.9
1.12	1924	255	101	81.5
1.13	2107	208	103	89.4
1.14	1460	158	75.7	43.5
1.15	2253	241	114	90.3
1.16	2294	256	124	89.3
1.17	1225	180	71.6	54.0
1.18	1957	187	121	84.7
1.19	1014	66.8	75.4	25.0
1.20	2266	162	87.1	47.2
1.21	1333	156	105	50.5
1.22	960	121	47.9	46.2
1.23	1336	110	56.5	26.6
1.24	1741	157	104	65.6
1.25	2216	207	121	94.1
1.26	735	69.0	81.6	28.6
1.27	1534	82.1	60.0	39.0
1.28	1522	92.9	77.2	27.9
1.29	1370	85.7	141	86.0
1.30	1118	100	117	87.8
1.31	282	77.9	103	50.0
1.32	1468	81.9	107	54.7
1.33	1782	185	122	88.9
1.34	965	110	74.2	31.2
X	1442	144	91.4	60.1
SD	563	62.2	24.1	24.0

Table 2. Mustard sauces with grain: macroelements composition (mg/100 g)

Sample	Na	K	Ca	Mg
3.1	2110	179	132	97.5
3.2	1423	208	128	92.3
3.3	1975	203	104	71.5
3.4	2053	188	127	76.5
3.5	1863	152	120	73.0
3.6	2100	166	139	74.8
X	1921	183	125	80.9
SD	261	21.5	12.2	11.0

Table 3. Mustard: macroelements composition (mg/100 g)

Sample	Na	K	Ca	Mg
2.1	165	425	476	310
2.2	< 17	723	559	250
2.3	< 17	460	460	292
2.4	49.7	476	334	231
2.5	340	472	234	356
2.6	225	467	347	257
X	195	504	402	283
SD	121	109	118	45.8

are shown in Table 3. The relationship between potassium, calcium and magnesium is an indicator of the vegetable origin of the mustard.

Mustard seeds do not contain high levels of sodium (Table 3); therefore its presence in mustard sauces (Tables 1 and 2) may be due to the addition of sodium chloride during the preparation of the sauces (Presidencia del Gobierno, 1984). Certain components, such as potassium salts used as preservatives, also contribute to increase the potassium levels (Table 3).

The mean value of sodium found in the sauces studied (1442 ± 563 mg/100 g) is similar to those reported by different authors (Elmadfa *et al.*, 1989; Jimenez-Cruz *et al.*, 1994; Mataix-Verdu *et al.*, 1995). Sample number 1.31 shows the minimum content with 282 mg/100 g, according with the information from the label: 'sweet mustard'. The concentrations obtained for potassium, calcium and magnesium are also related to that cited in the literature. Levels of 130–160 mg K/100 g, 80–124 mg Ca/100 g and 48–84 mg Mg/100 g have been cited (Agricultural Research Services, 1963; Dien and Tentner, 1975; Osborne and Voogt, 1978; Elmadfa *et al.*, 1989; Jimenez-Cruz *et al.*, 1994; Mataix-Verdu *et al.*, 1995).

Among the microelements analysed, iron and zinc are present in high concentrations (Tables 4–6). Pérez-Bueno (1994) reported very low levels of iron in mustard seeds (0.06–0.1 mg/100 g) compared to our data (Table 6). Samples 2.5 and 2.6 show the maximum values of iron, with 12.4 and 10.1 mg/100 g, and of zinc, with 6.45 and 8.60 mg/100 g, respectively. In relation to the sauces (Tables 4 and 5), iron concentrations are similar to those reported by other authors (Osborne and Voogt, 1978; Pruthi, 1980; Elmadfa *et al.*, 1989; Jimenez-Cruz *et al.*, 1994; Mataix-Verdu *et al.*, 1995).

Copper and manganese show very low values in all the samples analysed. However, Pérez-Bueno (1994) indicated copper levels for mustard seeds even lower than those found by us (0.35–0.45 mg/100 g).

Statistical study

To conduct the discriminant analysis the mean values of all elements studied were used. The classification matrix shows that not all the samples are correctly classified (Table 7). Four samples from mustard sauces (1.4, 1.5, 1.7 and 1.11) are classified as belonging to mustard sauces with whole grain; the other samples are correctly classified in their corresponding group (2, 3).

The discriminant function coefficients (Table 8) enable us to represent graphically all the cases. Figure 1 is a plot of the first two discriminant functions for the mustard seed or flour and mustard sauces studied. It can be seen that mustard seeds clearly differentiate from the mustard sauces, in relation to the first discriminant function. With respect to the second one, groups 1 and 2 are in the neighbourhood and some of their samples

Table 4. Mustard sauces: microelements composition (mg/100 g)

Sample	Cu	Fe	Mn	Zn
1.1	0.22	1.76	0.34	0.87
1.2	0.16	1.75	0.37	0.52
1.3	0.15	2.47	0.41	0.72
1.4	0.17	1.90	0.41	0.68
1.5	0.16	1.49	0.51	1.21
1.6	0.24	1.82	0.43	0.95
1.7	0.24	1.85	0.51	1.19
1.8	0.25	3.33	0.62	0.84
1.9	0.24	2.25	0.51	1.23
1.10	0.16	1.33	0.33	1.27
1.11	0.30	2.52	0.64	0.72
1.12	0.18	1.72	0.42	1.21
1.13	0.20	1.65	0.39	1.00
1.14	0.14	1.69	0.37	0.54
1.15	0.20	1.62	0.39	0.81
1.16	0.41	1.93	0.43	1.51
1.17	0.18	1.73	0.33	0.68
1.18	0.14	1.38	0.35	0.77
1.19	0.17	1.66	0.32	0.56
1.20	0.24	2.24	0.31	0.64
1.21	0.30	2.17	0.43	0.75
1.22	0.39	1.34	0.27	0.44
1.23	0.33	1.34	0.15	0.33
1.24	0.27	1.65	0.42	1.01
1.25	0.27	2.35	0.44	0.97
1.26	0.10	1.67	0.30	0.65
1.27	0.19	1.81	0.21	0.51
1.28	0.15	1.86	0.30	0.66
1.29	0.43	2.22	0.46	0.93
1.30	0.27	1.60	0.35	0.81
1.31	0.24	1.22	0.26	1.27
1.32	0.09	2.66	0.31	0.61
1.33	0.49	1.58	0.46	1.22
1.34	0.11	1.80	0.32	0.60
X	0.22	1.86	0.38	0.84
SD	0.09	0.43	0.10	0.28

Table 5. Mustard sauces with grain: microelements composition (mg/100 g)

Sample	Cu	Fe	Mn	Zn
3.1	0.31	1.92	0.67	1.07
3.2	0.30	2.02	0.68	0.82
3.3	0.23	1.77	0.58	1.17
3.4	0.30	1.86	0.49	0.86
3.5	0.26	1.71	0.54	0.74
3.6	0.25	2.75	0.65	0.86
X	0.27	2.00	0.60	0.92
SD	0.03	0.38	0.07	0.16

Table 6. Mustard: microelements composition (mg/100 g)

Sample	Cu	Fe	Mn	Zn
2.1	0.66	7.68	2.18	4.50
2.2	1.58	7.67	2.95	5.71
2.3	1.83	7.76	2.61	4.27
2.4	1.13	7.64	2.05	2.28
2.5	2.75	12.4	2.60	6.45
2.6	0.95	10.1	2.22	8.60
X	1.48	8.87	2.43	5.30
SD	0.75	1.75	0.34	2.15

Table 7. Classification matrix

Group	Correct percentage	Number of cases in each group		
		Mustard seeds	Mustard sauces with grain	Mustard sauces
1[a]	88.24	0	4	30
2[b]	100.00	6	0	0
3[c]	100.00	0	6	0
Total	96.08	6	10	30

[a]Mustard sauces.
[b]Mustard (seed, flour).
[c]Mustard sauces with grain.

Table 8. Discriminant function coefficients

Variable	Coefficients	
Na	−0.45239	1.13780
K	0.16835	−0.95143
Ca	0.27862	−0.66218
Mg	0.46139	0.02957
Cu	−0.38460	−0.68779
Fe	0.62541	−0.53653
Mn	0.52020	1.55766
Zn	−0.15060	−0.18481

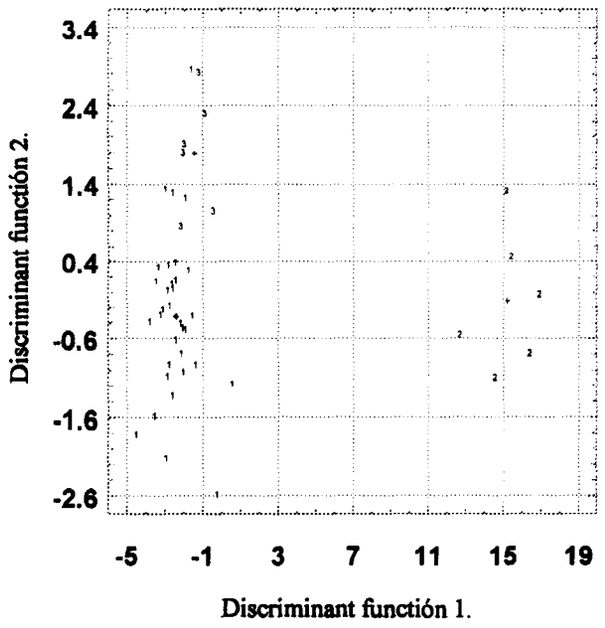

Fig. 1. Discriminant analysis of mustard samples.

Table 9. Correlation matrix of mineral composition

Na	K	Ca	Mg	Cu	Fe	Mn	Zn
Na							
K	−0.3703						
Ca	−0.5679	0.8832					
Mg	−0.4968	0.8842	0.8768				
Cu	−0.5308	0.7788	0.7184	0.8748			
Fe	−0.6298	0.8176	0.8077	0.9261	0.8898		
Mn	−0.6230	0.9091	0.9335	0.9439	0.8833	0.9405	
Zn	−0.5563	0.8193	0.8054	0.8827	0.7949	0.9179	0.8957

overlapped. Samples 1.4, 1.5, 1.7 and 1.11, belonging to group 1, are positioned very near to group 3.

The correlation matrix (Table 9) shows significant positive high correlations between all the components of the mineral fraction. Only sodium showed negative correlations with the other elements considered. The higher correlation observed was that between manganese and magnesium (0.9439).

High positive correlation (0.9290) was found between sodium and chloride in a related study (López-Argüello, 1996) in which a high correlation was also found between the other components of the mineral fraction and water, in a negative way, and protein, fat and sinigrin, in a positive one. The relationship between all the components of the mineral fraction, except sodium, is an indicator of the use of mustard seeds in the preparation of the sauce. Thus each of them could be a useful quality index for mustard sauces. The mineral contribution of additives would only be significant for sodium.

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