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Mineral content of gurumelo (*Amanita ponderosa*)

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Abstract

A total of 116 gurumelo mushroom samples (*Amanita ponderosa*) from diverse areas in six towns in the provinces of Huelva, Jaén and Seville (Spain) were analysed. Each sample obtained was accompanied by extensive information on its localization (town, land type, incidence of the sun, predominant vegetation in the area, neighbouring vegetation, proximity of highways, urban nuclei or mines), besides a detailed classification of its morphology and of its development. The determinations of copper, iron, zinc, manganese, calcium and magnesium, were carried out by flame atomic absorption spectrometry. Sodium and potassium were done by flame atomic emission, and phosphorus by UV–V spectrophotometry. The mean values (±S.D.) obtained were, moisture: 88.8%±3.0%, Cu: 23.0±12.5 mg/kg, Fe: 88±86 mg/kg, Mn: 11.2±13.2 mg/kg, Zn 8.2±3.0 mg/kg, Ca: 85±38 mg/kg, Mg: 85±27 mg/kg, Na: 78±51 mg/kg, K: 3362±1412 mg/kg, P: 7.7±2.4 mg/kg. The subsequent statistical studies showed little relationship of the factors studied to the gurumelo's mineral contents.

Keywords: *Amanita ponderosa*; Mushroom; Minerals; Trace elements

1. Introduction

Since the mid 1980s, Spanish society has shown an increasing interest in natural wild products from woods, fields, foothills and uncultivated areas (asparagus, golden thistles and mushrooms).

This rise in popularity has been related to society's need for some form of recreation in the past few years, since, in many instances, the aim has not been to trade with these natural products, but simply the gratifying activity of visiting the countryside to collect, and later consume, them. This is sometimes interpreted as being an instinctive reminder of our ancestral hunting–harvesting period, expressed in this manner in times when we are being confined to urban areas (Moreno-Arroyo, Gómez, Jiménez, & Infante, 1996).

Nowadays, the appearance of mushrooms after the autumn or spring rains is an important event, which inspires the massive migration of people into the countryside to pick them, both for their consumption and sale. Their culinary popularity is such that "Mushroom Reserves" are appearing all over Spain, and mycophagists actually compete with each other in order to obtain one of these delicacies.

With regard to the gurumelo (*Amanita ponderosa*) (Fig. 2), in recent years a true mycological culture has begun in western Andalusia (mainly in Huelva and Seville), so that in places such as Calañas in March there is an actual festival, whose "queen" is this mushroom, with gastronomy, art and singing contests, accompanied by talks of a technical and propagative nature, to help to understand and acquire knowledge on mushrooms, as well as on their differential characteristics (Jarillo, 1999).

Thus the gurumelo has become one of the most prized mushroom species in Spain, and this delicacy reaches high prices on the market. A profound technical knowledge is therefore required of a product that is so eagerly consumed, especially with regard to its nutritional value and components, and this work aims to serve that purpose.

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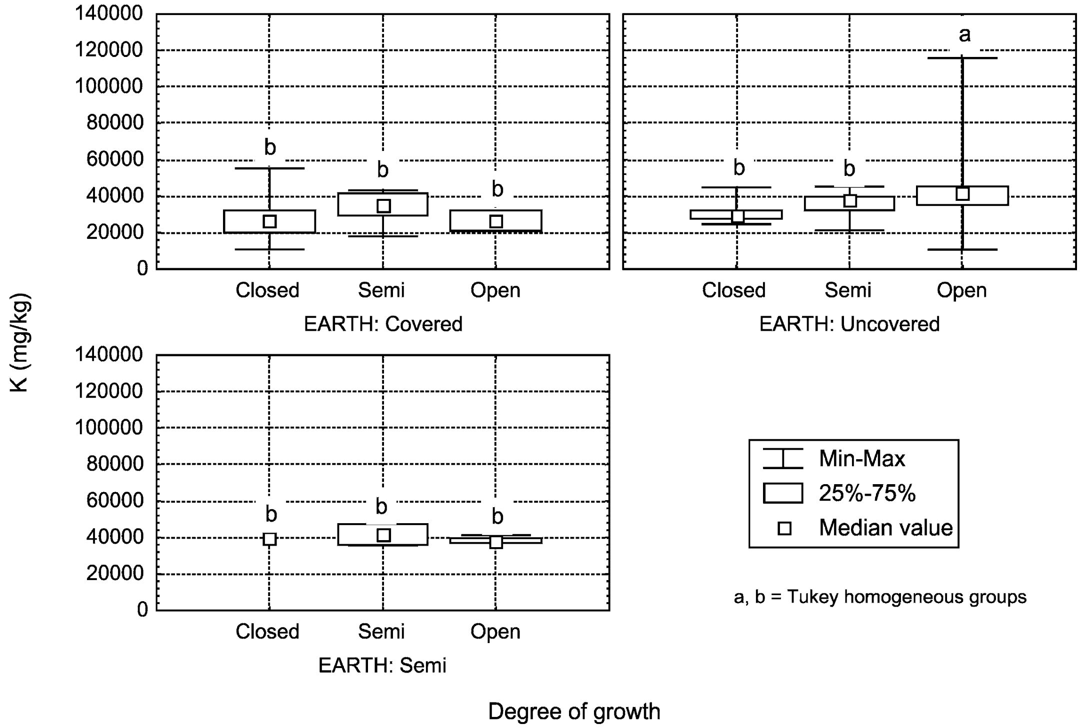

Fig. 1. Content of potassium in gurumelos (*Amanita ponderosa*) differentiated according to degree of earth covering and of growth. a, b, Tukey homogeneous groups.

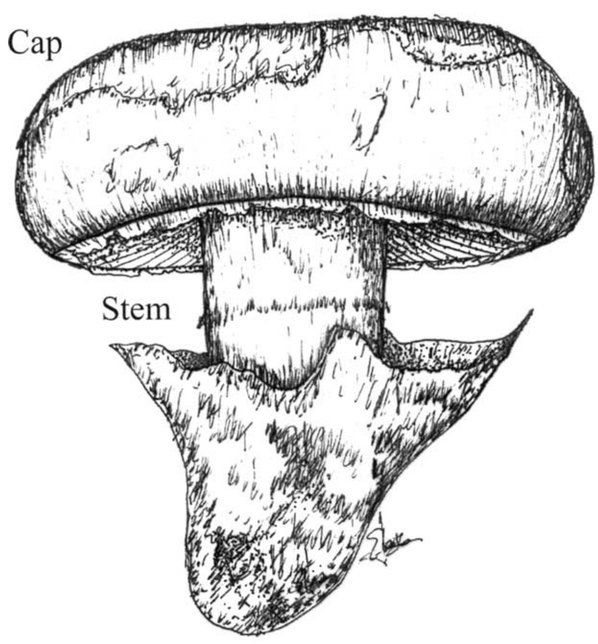

Fig. 2. Aspects of the Amanita ponderosa. Drawing by courtesy of Elena Pulido Calmaestra.

1.1. Study area

The study area is circumscribed by all the Andalusian provinces in which the habitat required by this species is known to exist, i.e. acidic substrates on which acidophilic cork and oak trees grow; in general, this is all the northern area of Andalusia occupied by the Sierra Morena foothills. This habitat has also been described in Portugal, for the first time in 1931, in the Sierra de Mochique, Mata do Pinheiro (Pinho-Almeida, 1994).

During the months of February, March, April and May different sub-sections were traced in the natural areas of the regions cited in the study area. For this purpose, the species' habitats were chosen and they were then searched and the mushrooms collected. The material was weighed and placed in paper envelopes for its later laboratory study.

1.2. Taxonomic description of the gurumelo, Amanita ponderosa *Malençon & Heim (Malençon 1942)*

The gurumelo is a large mushroom with a cap 8–17 cm in diameter, sometimes reaching 22 cm, with a hemispheric morphology when young and convex-plane in maturity, with a slight depression in the centre. The edge of the cap is curved inwards with (occasionally) the remainder of a partial veil. The cuticle is smooth and easily detached like a ''potato peel'', whitish cream in colour at the beginning, turning reddish brown with age or bruising. The hymenium is constituted of broad laminas, only slightly serrated, free or subadnated, with few lamellae, white but soon going ochraceous and red-mottled. The stipe is cylindrical, partly smooth to slightly fibrillose, from 7–13 cm long and 2–5 cm in diameter, paler in colour than the cap or showing pinkish-brown hues; it has an unclear annulus, broken up by the growth of the carpophore, the remainder like threads surrounding the stipe. The base of the stem is constituted by a membranous volva, the same colour as the rest of the fruiting body, able to become, sac-like, half the height of the stipe. The flesh is firm, very compact, white, but pinkish when in contact with the air, with a pungent flavour and odour, like damp earth. The spores are clumped or scattered and white when fresh, cream when dry. Under the microscope their claviform tetrasporic basidia stand out, with smooth elliptical transparent, amyloid spores, of 11–16×6–7 μm, with a patent lateral apicle.

In this study, it was hoped not only to determine the composition of inorganic components in the gurumelo (*Amanita ponderosa)*, but also to attempt to supply evidence of those controllable factors which could affect the mineral content. In this sense, these were the localization site, both its geography and the orography of the area, and the degree of growth of the mushroom at the moment of collection.

2. Material and methods

2.1. Samples

The contents of copper, iron, zinc, manganese, calcium, magnesium, sodium, phosphorus and potassium in 116 samples of *A. ponderosa* were analyzed from different areas in 6 locations in the provinces of Huelva, Jaén and Seville (Andalusia, Spain). Each sample obtained was accompanied by extensive information on its localization (location, type of land, incidence of sun, vegetation predominant in the area, neighbouring vegetation, proximity of highways, urban nuclei or mines), as well as a detailed classification of its morphology, depending on the state of growth when found.

2.2. Treatment of samples

For the mineral composition analysis of the mushroom, the dry mineralization method described by Moreno Rojas, Sánchez-Segarra, García-Martínez, Gordillo Otero, and Amaro-López (2000) was used. Washed and homogenized mushroom (25 g) were weighed into porcelain crucibles, previously dried in a furnace at 100 °C to constant weight, from which, and from the initial fresh weight, the moisture content was calculated. Once dried the samples were incinerated in a muffle furnace at 460 °C for 15 h. The ash was bleached after cooling by adding 2 ml of 2N nitric acid, drying it on thermostatic hotplates and maintaining it in a muffle furnace at 460 °C for 1 h. Ash recovery was performed with 5 ml of 2N suprapur nitric acid, making up to 15 ml with O.1N suprapur nitric acid.

The determination of the phosphorus was carried out by the 991.25 colorimetric method indicated by the AOAC (1991) in solutions of samples resulting from the drying treatment previously described.

The determinations were carried out by flame atomic absorption spectrophotometry, except for sodium and potassium, which were analyzed by flame atomic emission. For the determination of all the elements, except potassium and phosphorus, it was necessary to dilute the samples 1/100, and, in the case of calcium and magnesium, lanthanum chloride ($LaCl_3 \cdot 7H_2O$) was added to make up a final concentration of 0.27% of the sample, in order to prevent anionic interferences, which might modify the result of the determinations.

Elemental analyses were performed with a Perkin-Elmer model 2380® atomic absorption spectrophotometer equipped with a Perkin-Elmer AS-50 autosampler, standard air–acetylene flame and single element hollow cathode lamps and background correction with deuterium lamp for manganese.

2.3. Optimization of the analysis procedure

The entire analytical procedure was tested for sensitivity, precision, accuracy and limit of detection (Analytical Methods Committee, 1987; AOAC, 1995; Horwitz, Albert, Deutsch, & Thompson, 1990; Long & Winefordner, 1983) in order to assess the degree of reliability which could be applied to the data generated by this investigation (Table 1). The sensitivity was defined as being the concentration required of an element (in mg/l) to produce a 1% absorption signal, comparable to a reading of 0.0044 absorption units. The precision of the method was established by the calculation of between-assay variation coefficients from the data of ten independent analyses, including the pretreatment steps, carried out at different times on a commercial mushroom sample. In order to check the accuracy of the method in the determination of Cu, Fe, Zn, Mn, Ca, Mg, Na, K and P, five samples of "Citrus Leaves" (Standard Reference Material, SRM1572), supplied by the National Bureau of Standards (NBS), were analyzed. The recovery percentages are shown in Table 1 and, from the results obtained, it can be seen that the recovery value means of all the mineral elements considered are found to be within the interval of confidence ($P < 0.05$) calculated for the value certified.

2.4. Statistical analysis

Data obtained were evaluated statistically by descriptive parameters; PROC GLM and Tukey's mean homogeneity test ($P < 0.05$) "Honest Significance Differences, HSD" (Molina-Alcalá, Delgado-Bermejo, Rodero-Franganillo, & Moreno Rojas, 1992; SAS, 1989). Data were normalized using Log $(x+1)$ transformation.

Table 1
Instrumental conditions and limit concentration values, sensitivity, precision and analyis of Citrus"Citrus Leaves" (SRM1572)

Element	λ/Slit (nm)	Concentration limit (mg kg^{-1} dry weight)	Precision (coefficient of variation%)	Sensitivity (mg l^{-1})	"Citrus leaves" (mg kg^{-1})			
					Certified[a]	Found[a]	I.C. (95%)[b]	(rec., CV%)[c]
Cu	324.8/0.7	0.053	1.36	0.094	16.5 ± 1	17.1 ± 0.35	16.4–17.8	(104%, 2%)
Fe	373.7/0.2	0.843	0.98	0.743	90 ± 10	92.2 ± 1.00	90.3–94.2	(103%, 1%)
Zn	214/0.7	0.755	1.16	0.363	29 ± 2	29.1 ± 0.88	27.3–30.8	(100%, 3%)
Mn	280/0.2	0.218	1.35	0.061	23 ± 2	22.8 ± 0.15	22.5–23.1	(99%, 0.7%)
Ca	423/0.7	11.8	1.22	0.077	31,500 ± 1000	32,253 ± 821	30,644–33,862	(102%, 2%)
Mg	285/0.7	18.00	1.20	0.088	5800 ± 300	5749 ± 40	5671–5827	(99%, 0.7%)
Na	589/0.2	–	3.90	–	160 ± 20	173 ± 33	108–238	(108%, 19%)
K	767/0.2	–	1.35	–	18,200 ± 600	17,745 ± 501	16,763–18,727	(97%, 3%)
P	400/–	1.04	2.12	0.051	1300 ± 200	1287 ± 38	1212–1362	(99%, 3%)

[a] Each mean value is accommpanied by its typical deviation.
[b] Intervals of confidence (95%).
[c] Recovery percentages and variation coefficients (VC%).

3. Results and discussion

3.1. General

The gurumelos studied had the following composition of major constituents: water 87.8%, carbohydrates 6.6%, proteins 3.2%, fat 0.5% and fibre 1.5% with a calorie supply calculated at 42 kcal/100 g of the product, which characterises them, like most mushrooms, as being low-calorie foods.

With regard to the mineral composition, which was the basic objective of the study, Table 2 shows the mean values for the main grouping factors.

Although there are obvious differences between the means according to the factors studied, in most cases they were not statistically significant, due to their high internal variability.

Given that the Shapiro–Wilks W test indicated that the elements studied did not follow a normal distribution, a logarithmic transformation (Log $[x+1]$) was made of the data, which provided a good fit to normality for all the elements investigated and their moisture. This logarithmic transformation was used for the subsequent statistical analyses.

3.2. Effect of the geographical localization

To study the possible effect of the geographical collecting site, analyses of variance were made on the variables transformed, using, as clarification factors: the province, the location and the location area in which the mushroom was collected. The area selection (in Table 2 numbered from 1 to 17) obviously corresponded to places in which gurumelos were found, so that the greater abundance in some places than in others corresponds to the distribution of the appearance of the mushrooms and the collectors' capacity to find them.

Only the differences between provinces in the sodium content of the mushrooms, both in fresh and dry weight, were statistically significant ($P < 0.05$). In both cases, the mushrooms from Huelva had higher levels and those from Jaén formed the group with the lowest concentrations.

The differences between locations in moisture, iron, sodium and potassium were significant, with different levels of significance.

The study between areas demonstrated the existence of statistically significant differences for a greater number of the elements investigated. Only the differences ($P > 0.05$) for copper and magnesium, both in fresh and dry weight, were not significant.

The Tukey (HST) homogeneity of means test made a posteriori gave evidence of the formation in most cases of two homogeneous groups, to which all the areas belonged, except for one or two which only belonged to one or other of the groups.

Area 6, corresponding to Calañas in Huelva, was where the greatest concentrations of iron, sodium and potassium were found, although the presence of high levels for the remaining elements was not so constant in any of the areas.

In addition to the topographical classification, other factors were taken into account, such as orientation (shade, sun and flatness) and the vegetation predominant in the area and that nearest to the mushroom. These factors did not show any significant differences for any of the elements investigated.

3.3. Effect of the degree of earth covering and the mushroom growth

The study of these two factors was tackled jointly and the existence in them of interactions for some of the elements investigated was verified.

Table 2
Mineral contents of gurumelos (*Amanita ponderosa*) according to origin and degree of earth covering and of growth on finding them

Location	Area	No.	H_2O (%)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	K (mg/kg)	P (mg/kg)
Huelva												
Beas	1	3	91.1±0.8	16.4±1.8	49±6	3.7±3.0	6.3±1.3	79±40	73±8	67±14	3167±185	6,9±0,8
Calañas	2	2	90.6±0.8	14.8±1.6	82±40	2.5±0.8	6.3±0.5	34±3	61±9	59±16	3683±103	6,5±1,3
Calañas	3	37	89.2±2.1	20.9±9.7	70±65	7.2±8.8	7.5±1.9	87±29	83±21	72±37	3134±993	7,5±1,9
Calañas	4	17	89.0±4.9	18.7±12.3	73±70	9.7±4.8	7.7±3,5	64±25	80±35	74±37	4046±2322	6,9±2,7
Calañas	5	4	91.0±1.2	21.6±8.8	80±37	3.1±1.7	5.6±1.7	60±11	77±21	58±28	2782±792	6,0±1,9
Calañas	6	2	91.6±1.0	28.3±20.6	180±43	8.5±3.4	10.7±6.3	98±13	75±2	132±3	3815±1383	5,6±1,5
Calañas	7	3	88.7±2.7	37.9±15.3	127±65	46.0±38.8	10.8±2.5	120±35	107±16	140±54	4250±793	9,5±1,8
Calañas	8	3	85.5±1.4	31.1±2.2	64±10	30.1±15.0	8.5±0.5	142±7	89±9	34±5	2947±339	8,7±0,2
Calañas	9	3	89.6±1.6	25.7±7.7	194±144	7.6±3.0	12.2±1.9	75±31	120±40	122±95	6089±2395	10,3±1,5
Calañas	10	4	91.8±0.7	14.5±1.9	66±22	4.7±1.2	6.4±0.9	86±22	78±26	204±76	2693±85	5,7±0,2
Calañas	11	1	91.0	16.7	8	1.2	9.4	66	75	52	4034	8,6
Calañas	12	8	89.6±2.3	23.6±10.8	93±45	22.5±13.3	9.2±2.1	103±37	90±16	113±52	3618±1149	7,3±2,2
Calañas	13	5	86.7±0.3	36.0±24.4	29±8	21.2±13.7	11.4±3.1	61±13	93±9	76±14	3125±418	10,6±1,4
Carboneras	14	10	85.1±2.0	26.0±12.7	215±145	11.5±8.3	10.4±4,2	119±67	106±42	70±34	3457±1155	9,4±3,7
Sta. Barbara	15	5	87.7±0.4	22.8±2.9	47±15	12.4±8.5	7.5±0.7	66±10	70±5	58±19	2308±342	6,7±1,1
Jaen												
	16	6	87.8±1.0	31.5±10.8	108±36	11.4±8.9	7.6±1.5	99±9	82±9	28±4	2930±387	7,6±1,2
Sevilla												
El Pedroso	17	3	88.5±0.8	22.7±11.0	26±7	6.5±1.7	6.2±0.8	70±7	67±5	38±9	2241±211	8,3±1,0
Earth	State											
Covered	Open	2	87.0±2.0	41.9±2.4	112±27	20.4±2.5	9.6±1.7	79±12	93±9	101±3	3362±168	8,0±0,5
	Semi	9	90.1±2.4	16.4±8.7	91±44	13.3±10.4	7.3±1.5	95±19	81±12	61±21	3315±509	7,1±1,3
	Closed	61	88.7±2.3	23.9±13.0	87±97	12.7±15,9	8.1±3,1	90±42	84±25	83±55	2937±868	7,6±2,3
Semicovered	Open	4	90.6±0.6	15.8±3.7	151±95	11.9±12.7	8.1±1,9	86±56	79±20	78±29	3586±142	7,2±1,4
	Semi	2	92.0±0.2	11.6±0.9	37±13	18.2±1,8	9.4±0.6	66±1	65±4	90±29	3314±528	5,9±0,6
	Closed	1	92.9	15.0	30	3.7	5.5	81	58	87	2840	6,0
Uncovered	Open	10	85.9±5.6	19.8±14.0	128±102	8.7±5.3	10.1±4.9	71±33	113±52	114±78	5993±2964	9,0±3,8
	Semi	11	89.3±2.9	27.8±9.8	67±51	5.4±3.5	8.2±2.3	73±22	83±17	63±23	3772±669	8,2±2,7
	Closed	10	89.7±1.8	18.5±8.9	51±39	6.0±10.8	7.8±1.9	77±41	81±16	68±24	3147±664	7,5±2,3
Total	116	88.8±3.0	23.0±12.5	88±86	11.2±13.2	8.2±3.0	85±38	85±27	78±51	3362±1412	7,7±2,4	

Very few of the elements showed statistically significant differences, one of them being potassium, both in fresh and dry weight, for both factors. In the case of the analysis of variance for the growth factor, statistically significant differences were noted in the moisture and the magnesium content only in fresh weight, which showed that the differences detected for this last element really corresponded to differences in the degree of moisture.

The Tukey means homogeneity test, done a posteriori, produced two groups, one formed by all the classes used, except for that of the uncovered, open mushrooms, which presented higher values (although highly variable as can be seen from Fig. 1), constituting the other homogeneous group.

3.4. Analysis of the variance of components

Given the variability of the results and that the factors studied do not appear to reveal the justification of that variability, an analysis was made of the components of the variance in order to verify which of the factors studied accounted for the highest percentage of variability for each element, and the variability which had no explanation.

From this it was possible to confirm that, in most cases, the percentage of the non justified variability exceeded that of the clarified variability, and in the case of copper, magnesium and phosphorus, moreover, almost none of the variability could be explained by the factors studied.

The factors ''earth'' (localization of the mushroom on the surface or buried) and the degree of its ''growth'' had a great influence, especially on potassium and on the moisture. On the other hand, the geographical factors seemed to have a greater impact on the remaining variables, especially ''area''. The orientation of the mushroom (sun or shade) did not seem to justify very much of the variability in any of the elements investigated.

3.5. Study of specific cases and conclusions

The most obvious conclusion of the study was the lack of any justification for the variability observed in the gurumelo based on the factors studied. For that reason we have tried to find other causes for the variation, from factors rejected because of lack of information, and notes from the collectors with regard to the characteristics of the terrain or the proximity of nuclei of human activity and of highways.

In the individualized study of the data, some surprising features are observed, such as the appearance of higher levels of iron in two of three mushrooms that were found together, the third one having normal levels. This group obviously coincided with all the classification factors used, including the degree of development, so that it is difficult to find any justification for these differences.

Therefore, it seems logical to expect variations in the mineral content of the gurumelo although it is not possible to clarify its causes.

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References

Analytical Methods Committee. (1987). Recommendations for definition, estimation and use of detection limit. *Analyst*, *112*, 199–204.

AOAC (Association of Official Analytical Chemist), (1991). *Official methods of analysis* (1990), 15th ed; 2nd. supplement, 991.25: 101–102.

Horwitz, W., Albert, R., Deutsch, M. J., & Thompson, J. N. (1990). Precision parameters of methods of analysis required for nutrition labelling. *Journal Association of Official Analytical Chemists International*, *73*, 661–680.

Jarillo, T. (1999). Calañas: el gurumelo, tradición, fiesta y gastronomía. *Setas y Plantas*, *13*, 28–34.

Long, O. L., & Winefordner, S. D. (1983). Limit of detection: a closer look at the IUPAC definition. *Analytical Chemistry*, *55*, 712A–724A.

Molina-Alcalá, A., Delgado-Bermejo, J. V., Rodero-Franganillo, J. M., & Moreno-Rojas, R. (1992) *Introducción a la estadistica descriptiva e inferencial para investigadores*. *Procedimientos S.A.S.* Ed. by University of Córdoba, Centro de cálculo—Córdoba.

Moreno-Arroyo, B., Gómez, J., Jiménez, F. & Infante, F. (1996). *Setas de Andalucía*. Centro Andaluz del Libro.

Moreno Rojas, R., Sánchez-Segarra, P. J., García Martínez, M., Gordillo Otero, M. J., & Amaro López, M. A. (2000). Mineral composition of skimmed milk fruit-added yoghurts—nutritional assessment. *Milchwissenschaft*, *55*(9), 510–512.

Pinho-Almeida, F. (1994). Estudos taxonómicos no género Amanita. Secção Amidella-Complexo Lepiotodes: A. Curtipes Gilbert, A. Lepiotoides Barla e A. ponderosa Maleçon & Heim. *Revista. Biol.* (*Lisboa*), 15: 131–151.

SAS (1989) General lineal model (GLM) procedures. *SAS/STAT User's Guide*, 4 th edn. (Cary, NC:SAS Institute Inc) 45–52.