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Chemical composition of chestnut cultivars from Spain

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Abstract

Chestnut cultivation and production in Spain has employed grafted seedlings from selected local cultivars. Previously, we have characterised the Spanish cultivars by morphological and molecular markers. We are presenting in this paper the proximate analysis and mineral content for the main Spanish cultivars. A total of 131 samples were collected from 47 cultivars in six important Spanish chestnut production regions; located in the North such as Asturias, Castilla-León (El Bierzo) and Galicia; in the Central such as Extremadura and in the South such as Andalucía; as well as the Canary Islands, the southermost part of Spain near to North Africa. High variability in chemical composition between cultivars and regions corresponded to the high genetic variability between cultivars. Correlations with environmental parameters were low, indicating that differences found between regions were probably reflecting the differences between cultivars. In Central and Southern Spain, some cultivars presented lowest moisture content due to the low summer rainfall in these regions. Differences in starch and total sugar contents were high and were negatively correlated with each other. There was no negative correlation between nut size and total sugar content. Lowest values of fibre content and ease of digestibility were found in cultivars from Galicia and Extremadura. No significant differences in Fe, Zn and Cu were found although Zn content is twice the value reported for European chestnuts. This work would be a valuable reference to chestnut quality for the food processing industry, nutritionists, breeders and growers alike.

Keywords: *Castanea sativa*; Starch; Total sugars; Fibre; Fat; Ashes; Proteins; Minerals

1. Introduction

Chestnut (*Castanea sativa* Mill.) is a multipurpose species that is cultivated for timber, nut, tannin, and contributes positively to the forestry landscape. It is distributed mainly in the Northern Hemisphere, in Asia mostly in China, Korea and Japan, in Southern Europe from Turkey to Atlantic Islands and in the United States (Pereira-Lorenzo and Ramos-Cabrer, 2004). Chestnut was only recently introduced into the Southern Hemisphere such as Chile, Argentina, Australia and New Zealand.

There are three main chestnut growing areas in the world: (i) Asia being the most important, mainly in China, where *C. mollissima* is found naturally as well as in cultivation; (ii) Southern Europe and Turkey is the second main area where *C. sativa* is predominant; (iii) in North-America, *C. dentata* was widespread naturally but is being substituted by hybrids with resistance to blight.

Chestnut has been cultivated for nut production in Northern Spain, mainly in Vasque Country, Asturias, Castilla-León (El Bierzo) and Galicia, in Central Spain in Extremadura and in Southern Spain in Andalucía (Fig. 1), and also some in Eastern Spain in Cataluña. Chestnut crops have been introduced into the Canary Islands, since colonization in the 16th century. In all these areas, growers selected the best trees for nut production by propagation via grafting over seedlings (Pereira-Lorenzo et al., 2001a,b).

Previous studies on chestnut composition was only on starch content comparing the three main species (McCarthy and Meredith, 1988), who obtained a higher starch content, 49% in *C. dentata* and *C. mollissima* in respect to 40% in *C. sativa*. Ferreira-Cardoso et al. (1993) compared the main Portuguese *C. sativa* cultivars starch content and found the lowest, 50% in

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Benfeita and the highest, 59% in Lamela. Breisch (1995) explained the general values for the main chestnut nutrients and this work has formed the main basis for the current studies.

Although the selection of chestnut cultivars in Spain were made by nut quality such as big nut size, small number of polyembryonic nuts, and often for early harvesting (Ramos-Cabrer and Pereira-Lorenzo, in press), growers pointed out that some of the Spanish cultivars were sweeter or more easily digestible than others. We analysed the chestnut nutrients in order to assess if selection in respect to a scientific composition as a valuable resource for nutritionists, breeders and growers could be useful. This is the first comparative study of nutrient composition of Spanish chestnut cultivars from North to South and differentiating the main Spanish cultivars by their nutrient composition. It also provides a useful reference to the quality of each chestnut cultivar for the food processing industry, growers and breeders.

2. Materials and methods

2.1. Plant material

In this study, we have included 47 cultivars from six chestnut Spanish regions (Table 1; Fig. 1) (Pereira-Lorenzo et al., 2001a,b): 14 cultivars from Galicia, 9 from Asturias, 10 from Andalucía, 6 from Castilla-León (El Bierzo), 6 from Canary Islands (Tenerife) and 2 from Extremadura. These selected cultivars correspond to the most important cultivars in Spanish chestnut production. They were previously evaluated by morphology and isoenzymes to select the best cultivars in Galicia (Pereira-Lorenzo et al., 1996a,b; Ramos-Cabrer and Pereira-Lorenzo, in press). For statistical purpose, more than one tree was sampled for each cultivar, with a total of 131 samples analysed from these 47 cultivars.

2.2. Samples

One kilogram of chestnuts were collected in different regions of Spain at harvesting time (Pereira-Lorenzo et al., 2001a,b) and stored at 4 °C. Within a week, nuts were hand peeled, weighed and dried in an oven at 80 °C until a constant weight was reached to determine the moisture content. All samples were ground to flour for further analysis in Laboratorio Agrario e Fitopatolóxico de Galicia, Xunta de Galicia. Starch and total sugar content were assessed by a polarimeter using the Spanish Official Methodology (BOE, 2000). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the Van Soest detergent system (Van Soest et al., 1991) and crude fibre by AOAC (1990). For all fractions, fibres were determined using a Fibretec System (FOSS-Tecator). Fat content was estimated using a Soxtec System (FOSS-Tecator) (BOE, 1995). Crude protein was estimated as N-Kjeldahl applying 5.3 as a multiplicative factor (McCarthy and Meredith, 1988) using a digestor Gerhardt (BOE, 1995). Ash content was obtained by Spanish Official Methodology (BOE, 1995). Macro and microelements Ca, Mg, Na, K, Cu, Fe, Mn and Zn were determined by atomic absorption (AOAC, 1984) and P was estimated using a spectrophotometer UV–vis (BOE, 1995).

2.3. Statistical analysis

An analysis of variance (ANOVA) was conducted to estimate the effects of the region and the cultivar within region. The procedure PROC GLM of SAS for unbalanced data (SAS, 1988) was used according to the following model equation:

$$Xi(m)j = \mu + \mathrm{R}m + \mathrm{C}i(m) + \varepsilon i(m)j$$

where $Xi(m)j$ is the observation of the Cultivar i (i = 1–14) within the Region m (m = 1–6) and the sample j (j = 1–7); μ is the mean of all the observations; Rm, C$i(m)$ and $\varepsilon\ i(m)jk$ are the effects of the Region m, the Accession i within the Region m and the error associated to the sample k in the observation $i(m)j$, respectively. Student–Newman–Keuls multiple range test was used to indicate significant differences between means at the 5% level.

Pearson correlation coefficients were estimated for the environmental variables as annual average temperature, annual average rainfall, average rainfall during the summer period, and all the chemical components analysed in order to find possible relationships. In addition, Pearson correlation coefficients were estimated for the altitude and harvesting period of each sample with each chemical determination.

A principal components analysis (PCA) on the correlation matrix of the clone means of the nine main nutrients were carried out using the procedure PRINCOMP of SAS (SAS,

Table 1
Chestnut cultivars studied in the six regions from North to South of Spain

Region	Cultivar (number of accessions per cultivar in parenthesis)	Total cultivars	Number of samples
Andalucía	Capilla (3), Comisaria (2), Dieguina (2), Helechal (2), Pilonga (4), Planta Alajar (3), Rubia (3), Temprana (3), Tomasa (3), Vázquez (3)	10	28
Asturias	Chamberga (2), Doriga (2), Leinova (3), Llanisca (2), Mourisco (2), Rapuga (2), Valduna (2), Verdeta (2), Zapatona (3)	9	20
Canary Islands (Tenerife)	Castagrande (2), De Sala (2), Del Haya (2), Manso (2), Mulato (2), Redonda (2)	6	12
Castilla-León (El Bierzo)	Injerta (2), Marela (2), Negral (6), Parede (2), Rapada (2), Verdello (3)	6	17
Extremadura	Injerta (3), Verata (2)	2	5
Galicia	Amarelante (5), Famosa (5), Garrida (2), Inxerta (2), Longal (2), Loura (3), Luguesa (4), Marela (2), Negral (4), Parede (7), Presa (3), Raigona (3), Ventura (4), Verde (3)	14	49
Spain		47	131