Fruit Quality Characteristics of Important Chestnut Cultivars in Galicia, Spain

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ABSTRACT. The Galician region of Spain annually produces the largest chestnut crops in the country. Chestnuts are grown in Galicia from elevations of 10 to 1,100 m, usually on north-facing slopes in southern orchards. Harvest time ranges from 15 October to 15 November. From 1989 to 1991, 350 trees, representing 70 local cultivars were examined. The objective of the study was to select clones for distinctness, propagation and germplasm preservation. Fourteen principal Galician cultivars were investigated: Amarelante' (25 clones), `Bermella' (12 clones), 'Blanca' (12 clones), `Famosa' (10 clones), `Longal' (7 clones), `Loura' (9 clones), `Luguesa' (6 clones), `Negral' (11 clones), `Parede' (13 clones), `Presa' (7 clones), `Raigona' (14 clones), `Rapada' (17 clones), 'Ventura' (6 clones) and `Verde' (16 clones). For 3 yr, data was collected on the following characteristics: number of nuts per kg; shape; color; brightness; taste; ease of peeling; opened nuts; and, health.

The 28,689 ha of chestnut orchards in Galicia annually produce the largest volume of chestnut in Spain. Chestnuts are grown in Galicia between elevations of 10-1,100 m. Harvesting occurs during a 1-mo period, usually ranging from 15 October to 15 November (8).

Detailed descriptions have been published for many European chestnut cultivars. Italian cultivars have been described by Brevigieri (3, 4), Paglietta and Bounous (9), Fabbri et al. (7) and Bounous et al. (2). Casabianca and Vincensini (5) and Chapa (6) have published descriptions of French cultivars, and Portuguese cultivars have been summarized by Pimentel (11). In Spain, however, characterization of cultivars for nut appearance and quality has not been published previously.

The absence of standard descriptions for Spanish cultivars has caused problems in quality control of harvested nuts and in deciding which cultivars should be selected for new orchards establishment. There has been a lack of uniformity of nut characteristics due to the great number of cultivars grown in Galicia. In the past, it was important to plant several different cultivars with varying charac-

teristics and harvesting dates. The origin for these cultivars is usually unknown, although some history is available from old manuscripts.

During the years of 1989-1991, a research project was conducted to provide a standard characterization of different Spanish cultivars *(Castanea sativa* Mill.). This project was sponsored by INIA and the Direccion General de Montes, Xunta de Galicia. Nut samples were taken from 14 named cultivars grown in the Galician region. The objectives of the study were: characterize (13) and select the existing cultivars in Galicia in order to identify them; create a germplasm bank and propose a propagation of nuclear stock of the selected material (10); and, integrate the new cultivars into the nursery industry. We present some of the results on studies of nut quality characteristics of the main chestnut cultivars grown in Galicia.

MATERIALS AND METHODS

Plant materials. The information used to select the location of the study trees has been published in the Inventory and Distribution of the traditional chestnut cultivars in Galicia (8). Briefly, chestnut orchards at 65 different locations in Galicia were visited. A total of 353 trees, representing 70 cultivars, were selected for study. The trees were located in the most important production area in Galicia and represented the highest possible variability within each cultivar. From this sample base, 14 primary cultivars were selected, based on widespread planting in the different production areas and their familiarity to chestnut growers. During a 3-yr period, 1989-1991, attempts were made to sample each tree. Variation in sample numbers among the different years was caused by budgetary fluctuations.

Sampling. The samples were usually gathered directly from the ground with the burr present when possible. A minimum of 1 kg of nuts was collected from each tree, excluding nuts that were clearly defective. In some instances, the sample number of a specific cultivar was higher than the number of trees sampled (Table 1). This variation was due to multiple samples from the same tree, and the occasional collection of samples, by the owner, that did not belong to a marked tree.

Table 1. Number of sampled trees and total number of evaluated samples among 14 chestnut cultivars (*C. sativa*) in Galicia.

	Sampled trees			Evaluated samples		
Cultivar	1989	1990	1991	1989	1990	1991
Amarelante	14	25	10	29	31	10
Bermella	5	5	3	5	5	3
Blanca	12	12	3	14	12	3
Famosa	10	10	4	19	12	4
Longal	9	7	5	9	8	5
Loura	1	9	9	1	9	9
Luguesa	6	4	6	9	5	6
Negral	9	11	3	18	12	4
Parede	12	13	4	23	14	4
Presa	7	6	3	18	9	3
Raigona	9	14	8	10	15	8
Rapada	17	13	5	17	6	6
Ventura	5	6	5	5	6	5
Verde	15	16	6	16	19	6

Characteristics evaluated. Data were collected on samples from 3 different years, 1989, 1990 and 1991. The number of nuts per kg were determined. Length and width data (without measuring the hilum) were determined on 10 nuts per sample. Forty fruits (nuts with surrounding burr) per sample were observed for percentages of the pericarp opened (opened nuts), divided nuts and general resistance to insects, particularly *Balaninus elephas* Gyll. and *Laspeyresia splendana* Hubner. Some nuts in each sample were photographed to record color and brightness. Seven color/brightness groups were identified and one clone was selected to represent each color/brightness group. The representative clones were: 1) `Raigona' 3 from Carbalieda; 2) Parede' 22 from Fonagrada; 3) `Raigona' 9 from FologOso; 4) `Amarelante' 11 from Manzaneda; 5) `Lours' 12 from Parada do Sil; 6) `Negraf 5 from Rubia; and, 7) 'Verde' 11 from Folgoso. Each sample corresponded to each clone during the different years of sampling and was classified according to the following criteria. In 1989, data on taste, sweet, bitter or insipid, were taken from representative nuts of each sample. Peeling characteristics were evaluated in 1991, recording the time (in sec) to eliminate the endocarp and inner coat of 10 lateral nuts from each sample without damaging the kernal. Shape index was calculated by dividing nut width by height and multiplying by 100 (5). Nuts having an index between 90 and 99 were considered to be triangular (T), round (R) = 100, elliptical-triangular (ET) = 101 to 110, elliptical-short (ES) = 111 to 120, and elliptical-long (EL) > 120.

Statistical analyses. Data on each characteristic, with the exception of color and taste, were subjected to general linear model analyses (Procedure GLM) using SAS (12). Peeling time, worm damage, opened nuts, and divided nuts data were transformed using the arcsin (rootsquare x/100) formula prior to analyses. Mean separation were made by Student-Newman-Keuls multiple range test.

RESULTS AND DISCUSSION

Length, width and shape index. Two cultivars, Termella' and `Raigona,' exhibited high uniformity in these parameters, regardless of collection data (Table 2). The remaining cultivars showed significant differences in at least one of these parameters. The results indicated that nut length is more consistent than width or shape index over three years (Table 2). Width was consistent in the annual measurements of nuts from 5 cultivars, 'Bermella,' `Blanca,"Famosa,"Raigona' and `Rapada' (Table 2). Shape index appears to be more influenced by the yearly environmental fluctuations, with only three cultivars producing nuts with the same shape each year. However, these results could be misleading as there was intravarietal variability present. Cultivars `Amarelante,"Famosa,' `Longaf and 'Ventura' produced nuts with lengths greater than 3.0 cm during all years. The other cultivars produced small nuts, excepts for cultivars `Lours' and `Negral,' that reached 3.0 cm in one season. The width values normally average above 3.0 cm except in cultivars Parede,' and in cultivar `Longar in 1989. The most frequent shape of Gali-

cian cultivars is elliptical-short (9 of 14 cultivars), followed by elliptical-triangular (3 of 14 cultivars). Cultivars `Longal' and `Loura' are distinct, having triangular and elliptical-long shapes, respectively (Table 2).

Nuts per kg. Two cultivars, T'amosa' and 'Ventura,' consistently produced the largest chestnuts, i.e. < 100 nuts per kg (Table 3). Chestnuts from cultivars `Loura,"Amarelante,"Luguesa,"Negraf and Tresa' also were large, except in 1990. The remaining cultivars, `Bermella,"Blanca,"Longal,"Raigona,"Rapada,"Verde' and Tarede' usually produced smaller chestnuts, i.e. > 100 nuts per kg.

Opened and divided nuts. Differences among cultivars in the percentage of opened nuts (split pericarp) and divided nuts (polyembryonic) were found (Table 3). Cultivars `Amarelante,"Bermella,"Loura,"Parede' and `Raigona' have the smallest percentage of opened nuts, < 5%. The highest percentage of opened nuts (> 10%) were found in cultivars `Blanca,"Longal,"Luguesa' and 'Ventura.' Only chestnuts from 3 of 14 cultivars, 'Bermella,' `Raigona' and 'Blanca,' had a significant proportion of divided nuts (> 12%). Cultivar `Longal' had no divided nuts.

Peeling. The cultivar with the best peeling quality was Tarede,' taking less than 1 min per chestnut. Chestnut from cultivar `Longal,' the most popular cultivar, took between 1 and 1.5 min to peel. `Amarelante' chestnuts were the most difficult to peel (Table 4).

Health. Bergougnoux et al. (1) indicated that some cultivars may be resistant to *B. elephas* due to the density of thorns in the burr (1). In the present study, significant differences among the cultivars were found only in 1989, with cultivars `Longal,' exhibiting the greatest resistance (Table 5). The cultivars, `Blanca,"Famosa,"Loura,' Tarede,"Raigona,' and 'Verde' were least affected by infestations from *L. splendana.* Overall, the most resistant cultivars to both insects were, Tamosa' and Tarede' (Table 5).

Nut color. Color was difficult to evaluate due to the quick color/brightness degradation of the chestnut pericarp after peeling. The color range, yellow-red to brown, also posed problems because of the subjectivity of the evaluator. However, most samples could be assigned to a specific group (Table 6). There were large intracultivar differences, causing the assignment of some samples to atypical color groups for each respective cultivar. Differences were found among cultivars with chestnuts from cultivars: `Amarelante,"Fomasa,"Loura,"Rapada,' and `Ventura' typically were classified as Type 4; `Bermella,'

Table 2. Size (cm) and shape of lateral nuts for 14 cultivars from Galicia (Spain) in 1989, 1990 and 1991.

	Length (cm)			Width (cm)			Shape Index			
	1989	1990	1991	1989	1990	1991	1989	1990	1991	Shape
Amarelante	3.06bc	3.03bc	3.00b	3.47ab	3.33c	3.46a	113.50def	110.00cd	115.67ab	EC
Bermella	2.92cdef	2.91de	2.81bcd	3.15cd	3.12e	3.05f	108.08f	107.81d	109.82c	ET
Blanca	2.63g	2.69g	2.66d	3.18cd	3.07ef	3.08f	120.96bc	114.22bc	112.85bc	EC
Famosa	3.01bcd	3.12b	2.95bc	3.54a	3.45b	3.48a	118.09bcd	110.76bcd	115.84ab	EC
Longal	3.27a	3.26a	3.26a	3.13cd	2.94f	2.90g	96.15g	90.37f	90.92f	T
Loura	2.48h	3.00cd	2.65d	3.28bc	3.59a	3.24bcdef	132.33a	120.02a	120.48a	EL
Luguesa	2.86def	2.95cde	2.83bcd	3.56a	3.27cd	3.28bcde	124.65b	110.77bcd	116.10ab	EC
Negral	2.92cdef	2.70g	2.95bc	3.45ab	3.07ef	3.37abc	118.62bcd	114.58bc	114.51abc	EC
Parede	2.73fg	2.86ef	2.83bcd	2.97d	2.94f	2.82g	108.81f	102.76e	100.46e	ET
Presa	2.95cde	2.89ef	2.89bc	3.45ab	3.18de	3.39ab	117.20cd	110.26bcd	117.47ab	EC
Raigona	2.74fg	2.71g	2.68d	3.16cd	3.07ef	3.14def	116.19cde	113.34bc	116.28ab	EC
Rapada	2.87cdef	2.80g	2.63d	3.38abc	3.13e	3.13ef	117.98bcd	112.23bcd	117.49ab	EC
Ventura	3.16ab	3.06bc	3.21a	3.48ab	3.13e	3.32abcd	110.81ef	102.73e	105.00d	ET
Verde	2.78efg	2.71g	2.78cd	3.32abc	3.11e	3.19cdef	119.64bcd	115.03b	114.79abc	EC

Numbers followed by the same letter within columns, and means within lines are not statistically different at the 5% level.

Table 3. Number of nuts per kg, opened and divided nuts in 1989, 1990 and 1991 for 14 cultivars from Galicia (Spain).

	Nuts per kg			Opened nuts (%)			Divided nuts (%)		
Cultivar	1989	1990	1991	1989	1990	1991	1989	1990	1991
Amarelante	96ab	104ab	85bcd	5ab	3bc	0a	1.8ab	0.6abc	1.1a
Bermella	119ab	121ab	120b	1b	0c	0a	8.0a	2.5abc	12.5a
Blanca	119ab	145a	105bcd	19a	9abc	2a	3.7ab	2.3abc	11.5a
Famosa	97ab	95ab	83cd	9ab	8abc	4a	0.0b	0.3abc	0.0a
Longal	113ab	133ab	117bc	10ab	5abc	1a	0.0b	0.0c	0.0a
Loura		75b	96bcd		5abc	1a	—	0.8abc	5.8a
Luguesa	79b	109ab	96bcd	20a	18a	9a	6.7a	7.8ab	2.5a
Negral	93ab	141a	78d	4ab	7abc	0a	0.8ab	0.7abc	6.3a
Parede	129a	134ab	147a	4ab	4abc	1a	1.4ab	0.4abc	1.0a
Presa	87ab	111ab	86bcd	9ab	4abc	3a	2.1ab	0.8abc	0.0a
Raigona	118ab	146a	108bcd	3ab	0c	0a	7.9a	4.9a	12.8a
Rapada	93ab	115ab	112bcd	7ab	4abc	0a	0.8ab	0.3ab	7.9a
Ventura	79b	98ab	82d	0b	14ab	0a	0.0b	0.3abc	0.4a
Verde	96ab	122ab	108bcd	9ab	6abc	3a	1.4ab	1.6abc	3.2a

Number followed by the same letter within columns are not statistically different at the 5% level.

Table 4. Ease of peeling the pericarp and inner coat of lateral chestnuts from 14 cultivars from Galicia (Spain), measured in seconds.

Cultivar	Lateral
Amarelante	110.46a
Bermella	80.30ef
Blanca	88.57bcde
Famosa	71.21f
Longal	82.49cdef
Loura	98.32abc
Luguesa	92.75bcde
Negral	97.39abcd
Parede	55.94g
Presa	85.55bcdef
Raigona	95.90bcde
Rapada	98.92ab
Ventura	83.38cdef
Verde	81.83def

Number followed by the same letter within columns are not statistically different at the 5% level.

Table 5. Percentage of nuts affected by *Balaninus elephas* and *Laspeyresia splendana* in 14 chestnut cultivars in 1989, 1990 and 1991.

	Balaninus			*Laspeyresia*		
	1989	1990	1991	1989	1990	1991
Amarelante	13.08a	5.62a	10.90a	8.82ab	14.67ab	1.95a
Bermella	16.00a	7.36a	11.33a	8.90ab	18.43ab	15.67a
Blanca	13.72a	7.36a	8.33a	3.47b	7.65abc	7.50a
Famosa	5.24ab	4.69a	7.50a	8.90ab	9.83abc	6.13a
Longal	3.17b	1.50a	3.00a	5.38b	4.19bc	13.40a
Loura	–	4.61a	10.83a	–	2.39c	10.11a
Luguesa	6.51ab	1.40a	7.41a	4.41b	22.90a	3.17a
Negral	9.86a	5.91a	2.50a	5.42b	13.12ab	6.00a
Parede	5.32ab	1.29a	3.00a	7.99b	5.64abc	2.25a
Presa	15.89a	7.52a	5.00a	12.89ab	28.65abc	8.17a
Raigona	6.10ab	4.26a	2.38a	4.49b	10.00abc	5.75a
Rapada	13.86a	7.50a	4.58a	6.31b	17.28ab	8.67a
Ventura	13.29a	3.67a	3.30a	20.18a	16.08ab	5.80a
Verde	11.68a	2.85a	8.75a	5.17b	6.03abc	2.33a

Number followed by the same letter within columns are not statistically different at the 5% level.

Table 6. Fourteen chestnut cultivars (*C. sativa*) classified according 7 color/brightness groups.

	Color/Brightness Group						
Cultivar	1	2	3	4	5	6	7
Amarelante	4	10	7	31	1	–	–
Bermella	–	4	6	5	–	2	–
Blanca	3	7	9	6	3	2	–
Famosa	1	–	7	11	–	–	1
Longal	–	2	2	9	–	2	7
Loura	–	3	2	14	–	–	–
Luguesa	–	2	–	4	–	1	4
Negral	2	4	7	6	1	7	–
Parede	3	18	5	4	1	–	1
Presa	–	1	4	3	2	5	5
Raigona	4	13	5	7	2	3	–
Rapada	1	3	7	16	3	2	1
Ventura	–	2	–	8	–	–	–
Verde	1	3	20	11	–	–	2

Table 7. Clone classification of 13 cultivars studied in 1989 with regard to taste.

	Taste		
Cultivar	Sweet	Bitter	Tasteless
Amarelante	17	2	6
Bermella	3	1	1
Blanca	5	–	4
Famosa	10	–	2
Longal	5	–	4
Luguesa	2	–	1
Negral	14	–	3
Parede	13	–	3
Presa	7	–	4
Raigona	4	–	3
Rapada	6	1	3
Ventura	5	–	–
Verde	4	–	8

`Blanca' and 'Verde' were classified as Type 3; and, Parede' and `Raigona' were classified as Type 2. Color in other cultivars was less consistent.

Taste. Intra- and intercultivar variability in taste was detected (Table 7). Overall, the sweetest cultivars were Parede,"Negral,"Famosa,"Presa,"Amarelante,"Rapada,"Blanca' and 'Ventura.' Chestnuts from cultivars `Verde' were generally insipid. The greatest intracultivar variability in taste was found in cultivars `13ermella,' `Luguesa,"Lougal,"Blanca' and 'Ventura.'

The results clearly demonstrate the presence of intracultivar variability in each of the named Spanish cultivars, e.g. 'Verde.' This practice probably relates to the old cultural belief that the central chestnut of the burr develops a seedling that is identical to the maternal parent. Until further research can provide a basis for cultivar certification (Lorenzo and Fernandez, in preparation), nomenclature and performance standards for current Spanish chestnut cultivars can be regarded as *sensu law* instead of *sensu stricto.*

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