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Study of some physical characters and nutritive composition of the Portuguese's (local) almond varieties

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SUMMARY – The almond (*Amygdalus communis* L., or *Prunus dulcis* Miller) producing regions of Portugal are mainly Trás-os-Montes and Algarve. On the almond producing farms, there are an important number of local varieties with some interesting characteristics. Most of these varieties blossom when the risk of late frosts is high. For this reason, the farmers have abandoned them. In recent years field samples of various local varieties were collected and grafted on the GF-677 rootstock for germplasm maintenance and conservation. In the years of 1997 and 1998, an experiment was carried out to characterize its production. This work will present the results of 13 varieties, in which physical and nutritive composition of fruits were analysed. The first aim of this study is to contribute towards a better knowledge of the characters of the Trás-os-Montes (Portuguese) varieties, and initiate a breeding program for the next years. The 'Ferragnès' variety was used to compare with the Portuguese varieties. Results of this study reflected a diverse germplasm of hard-shelled almonds in the Trás-os-Montes region.

Key words: Almond, varieties, nut, kernel, characteristics.

RESUME – *"Etude de certains caractères physiques et de la composition nutritive des variétés portugaises d'amandier (locales)". Au Portugal l'amandier (*Amygdalus communis *L., ou* Prunus dulcis *Miller) est cultivé principalement dans les régions de Trás-os-Montes et Algarve. Dans les diverses explorations d'amandier, il existe un grand nombre de variétés avec quelques caractéristiques intéressantes. La plupart de ces variétés ont une époque de floraison quand le risque de gelée tardive est fort. Pour cette raison les agriculteurs sont en train d'abandonner ces variétés. Dans les dernières années certains échantillons de matériel ont été cueillis et greffés avec porte-greffe GF-677 pour conservation dans un champ de germoplasme. Dans les années 1997 et 1998 a été réalisé un essai pour caractériser la production de ces variétés. Dans ce travail on présente les résultats relatifs à 13 variétés, où leurs fruits ont été analysés physiquement et leur composition chimique determinéé. Le premier objectif de cette étude est de contribuer à une meilleure connaissance des caractéristiques des variétés portugaises, et commencer un programme d'amélioration dans un avenir prochain. La variété 'Ferragnès' a été utilisée pour confronter avec les variétés portugaises. Les résultats de ce travail montrent qu'il existe une grande diversité de variétés d'amandiers avec amande d'écorce dure dans la région de Trás-os-Montes.*

Mots-clés : *Amandier, variétés, amande, grain, caractéristiques.*

Introduction

The almond (*Amygdalus communis* L., or *Prunus dulcis* Miller) producing regions of Portugal are mainly Trás-os-Montes and the Algarve. In these two regions of our country, almond has been cultivated for a long time, however characterization of local varieties is limited. In addition, recent introductions of foreign varieties, more productive with blossom when the risk of late frosts is not high, will undoubtedly contribute to the genetic erosion of local varieties. Almond cultivation is important in Portugal due to several aspects, such as the high quality of its fruits, the large number of farmers involved and the large acreage of almond trees (Maia *et al.*, 1997).

Socias i Company and Felipe (1997) referring that several aspects have to be considered in almond fruit quality, not only the kernel organoleptic characteristics but also the physical aspects of the kernel and the shell. Berger (1969) reported that also the composition of the kernel, with the different proportions of proteins, lipids and sugars can define the best industrial use for each cultivar (Socias i Company and Felipe, 1997). Kester *et al*. (1977) studied the heritability of a large number of nut and kernel traits.

Kader (1996) defined that the quality of a shipment of almonds is a function of four factors: (i) appearance; (ii) kernel texture; (iii) flavour and nutritive value of the kernel; and (iv) absence of contamination. The best-tasting almonds have the desired properties of sweetness and oiliness.

The aim of this study is to contribute for a better knowledge of the characters of the Trás-os-Montes (Portuguese) varieties, and initiate a breeding program for the near future. Of the varieties introduced in Portugal the most important is 'Ferragnès' (French variety), because it's higher production per hectare. Another objective of this work is to compare the Portuguese varieties with 'Ferragnès'.

Materials and methods

The study was carried out in an experimental orchard at the "Centro Experimental da Terra Quente" located in Mirandela, in Northeast Portugal. Precipitation was about 600 mm per year and maximum air temperature around 38°C during the summer months.

The first varieties, grafted on GF-677 rootstock, were planted in 1991. At this time, forty-eight varieties were planted. The experimental design consisted of a randomized block with three-tree plot replicated two times. Of all the varieties, 13 were studied and compared with the most important foreign variety introduced in Portugal, the 'Ferragnès' variety.

During the years 1997 and 1998, a sample of a 100 fruits were collected from each variety for evaluation of the following traits: nut and kernel weight (g), length (mm), width (mm) and thickness (mm). Their respective ratios (width/length, thickness/length and thickness/width), shelling percentage (kernel weight/nut weight) and percentage of doubles (number of kernels per nut), were calculated. For cluster analysis (single linkage method – nearest neighbour) the physics characteristics (except doubles percentage) were used. The characterization of the nut and kernel shape (width/length ratio) was used for the almond descriptors by Gülcan (1985). Two samples of each variety, 1997 and 1998, were used for determination the nutritive composition of the kernel with tegument. They were broken in little bits, dried at 65°C during 24 hours and dry matter was determinate. Results were analysed by Anova and means were separated by the Fisher's LSD test. Both statistical analyses were carried out in Systat for Windows version 5.

Results and discussion

Nut weight of the varieties studied ranged between 4.207 to 10.530 g, length from 30.40 to 43.10 mm, width from 18.35 to 30.80 mm, and thickness 15.05 to 20.30 mm. Kernel weight ranged between 1.018 to 1.674 g, length from 20.05 to 31.05 mm, width from 11.60 to 17.00 mm, and thickness 7.10 to 9.60 mm (Table 1).

Some varieties had high percent, double kernel ranging from 10 in 'Duro Amarelo' to 25 in 'José Dias'. Duval *et al*. and Grasselly and Vargas *et al.* (1994) (cited in Talhouk *et al.*, 1997) referred a high percentage of double kernels is an undesirable trait that is dependent on both environmental and genetic factors. In 'Ferragnès', 'Bonita', 'Verdeal' and 'Gama' varieties this percentage was zero (Table 2). Shelling percentage ranged from 14.92% in 'Gama' and 33.61% in 'Bonita S. Brás'. Almost all varieties studied have a hard-shell nut. The kernel and nut shapes are function of the variety (Table 2).

The cluster obtained by the physics characteristic (Fig. 1) show in a dendrogram the relationships between varieties. In function of this can be suggested 3 groups of varieties (two varieties ungrouped and one group with three sub-groups).

The first subgroup includes 'José Dias', 'Duro Estrada', 'Bonita', and 'Duro Amarelo' varieties. These varieties have the shortest length of kernel and nut (Table 1), and the biggest thickness/length ratio (not showed) of kernel and nut, except for 'Bonita' variety. The second subgroup is 'Boa Casta', 'Verdeal', 'Mourisca', 'Bonita São Brás' and 'Ferragnès' varieties. The most important characteristic of this subgroup is the small nut thickness (<16.75 mm). With the largest kernel (<15.75 mm), except 'Gama' variety and the smaller kernel thickness/width ratio (<0.47), the third subgroup are 'Parada',

'Casa Nova' and 'Marcelina Grada' varieties. The ungrouped varieties are 'Saia Longa' has the bigger kernel length and 'Gama' has the bigger nut width, length and weight (Table 1).

Table 1. Biometrics nut and kernel characteristics of almond varieties (average of 100 fruits, 1997-1998)

Varieties	Weight (g)		Length (mm)		Width (mm)		Thickness (mm)	
	Nut	Kernel	Nut	Kernel	Nut	Kernel	Nut	Kernel
Casanova	6.924	1.311	35.65	27.00	27.20	16.20	17.35	6.55
Mourisca	6.057	1.205	35.50	23.05	23.00	14.15	16.75	8.05
Duro Estrada	5.459	1.018	30.55	20.05	23.60	13.35	15.10	8.55
Boa Casta	4.207	1.277	34.40	24.50	19.85	13.44	18.45	8.10
José Dias	6.103	1.115	31.00	20.70	24.85	13.30	20.30	8.85
Ferragnès	4.459	1.389	36.25	26.45	22.80	14.05	16.50	8.10
Parada	5.888	1.331	36.80	24.40	26.35	15.75	17.50	7.10
Saia Longa	5.875	1.402	42.55	31.05	20.35	11.60	16.10	8.05
Bonita São Brás	3.765	1.277	33.85	23.95	18.35	12.25	15.05	9.30
Marcelina Grada	8.201	1.674	36.95	25.75	27.15	17.00	19.20	8.00
Bonita	5.339	1.088	30.40	21.95	22.50	12.05	15.65	7.80
Verdeal	4.979	1.127	34.45	24.20	22.30	12.80	15.90	7.60
Duro Amarelo	4.588	1.304	31.80	22.55	20.60	13.00	17.40	9.60
Gama	10.530	1.590	43.10	28.65	30.80	16.50	19.75	7.10

Table 2. Commercial characteristics of almond varieties (1997-1998)

Varieties	Shelling (%)	Double kernel (%)	Kernel shape†	Nut shape†
Casanova	19.36	2	Broad	Oblong
Mourisca	21.83	7	Broad	Oblong
Duro Estrada	22.20	19.5	Extremely broad	Ovate
Boa Casta	30.00	1	Intermediate	Cordate
José Dias	21.63	25	Broad	Ovate
Ferragnès	30.93	0	Intermediate	Cordate
Parada	22.73	0.5	Broad	Cordate
Saia Longa	26.03	12	Extremely narrow	Extremely narrow
Bonita São Brás	33.61	2	Intermediate	Oblong
Marcelina Grada	20.53	6	Extremely broad	Oblong
Bonita	27.06	0	Intermediate	Cordate
Verdeal	21.74	0	Intermediate	Cordate
Duro Amarelo	29.53	10	Broad	Cordate
Gama	14.92	0	Broad	Oblong

†Gülcan (1985).

Table 3 shows the dry weight, proteins, lipids, fibre, ash and sugars percentages founded in the varieties analysed. Souty *et al.* (1971) analysed 13 varieties and obtained the following means for the biochimics: water contend 4.61%; lipids 56% (mean of 51 and 61); proteins 27.3% (mean of 24.4 and 31.9); sugars 5.0% (mean of 4.2 and 10.6).

Grasselly and Crossa-Raynaud (1980) referred that the percentage of lipids in almond kernel depends on the climate. However, the percentage of lipids depends on of the variety too. The results (Table 3) showed that the lipid amount varied significantly between varieties ($P < 0.001$). In this case, they are all in same place with the same clime. The lipids content varied between 49.046% ('Verdeal') and 58.873% ('José Dias'). Comparing with 'Ferragnès' variety and the results obtained by Souty *et al.*

(1971), some of the Portuguese varieties like 'Boa Casta', 'Duro Estrada' and 'José Dias' have a largest amount of lipids.

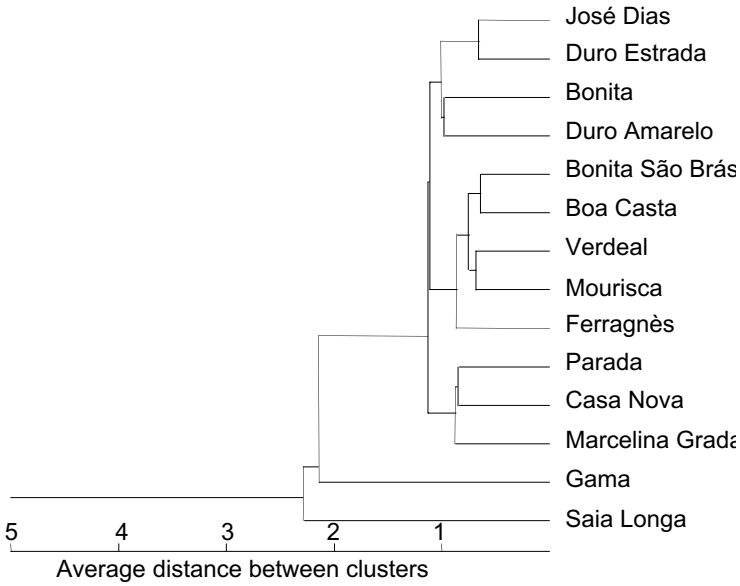

Fig. 1. Dendrogram of 14 almond varieties.

Table 3. Nutritive composition of almond varieties (1997-1998)

Varieties	Dry weight (%)	Proteins (%)	Lipids (%)	Fibre (%)	Ash (%)	Sugars (%)
Casanova	94.953 a	25.035 i	55.298 e	6.320 f	3.787 b	6.730 b
Mourisca	94.620 ab	26.802 f	55.272 e	8.368 cd	3.567 d	5.350 e
Duro Estrada	94.540 ab	22.601 m	58.410 b	8.063 d	3.506 e	6.030 d
Boa Casta	94.210 b	23.861 l	56.503 c	7.338 e	3.373 f	6.810 b
José Dias	94.113 b	22.755 m	58.873 a	6.545 f	3.569 d	5.255 e
Ferragnès	94.974 b	22.543 m	56.425 c	11.190 b	3.540 de	6.377 c
Parada	93.909 bc	24.275 j	53.767 g	11.788 a	3.673 c	6.762 b
Saia Longa	93.878 bc	29.028 d	51.354 i	7.793 de	3.788 b	6.345 c
Bonita São Brás	93.840 bc	25.629 h	54.480 f	5.108 g	3.535 de	5.868 d
Marcelina Grada	93.495 c	27.842 e	53.276 h	7.403 e	3.495 e	6.223 c
Bonita	93.420 c	29.709 c	53.337 h	6.445 f	3.558 d	4.985 f
Verdeal	93.387 c	31.281 a	49.046 l	7.048 ef	3.926 a	7.073 a
Duro Amarelo	93.301 c	26.379 g	55.345 d	8.738 c	3.450 e	5.227 ef
Gama	93.245 c	30.233 b	50.809 j	10.958 b	3.713 c	5.128 f

[a,b,c,d,e,f,g,h,i,j,l,m]Within each column, means followed by the same letter are not significantly different according to Fisher's LSD test.

The results indicated that 'Verdeal' variety was the lowest in lipids amount (40.046%), but is the highest in proteins (31.281%). Pandele (1966) (cited in Grasselly and Crossa-Raynaud, 1980) verified the same thing for other varieties. Lage (1974) founded a different value for lipids and proteins for 'Verdeal' variety.

'Ferragnès' had the lowest percentage of proteins (22.543%), and is not significantly different from 'Duro Estrada' and 'José Dias'. All the other varieties were significantly different ($P < 0.001$) (Table 3). The proteins amount can be considered high in 'Verdeal', 'Bonita' and 'Saia Longa' varieties.

Sugars amount varied from 4.985% in 'Bonita' to 7.073% in 'Verdeal'. The 'Boa Casta', 'Parada', and 'Casa Nova' varieties were presented as the largest sugar percentage with no statistical differences, except with 'Verdeal'.

Dry weight was dependent variable analysed that presented the smaller variation between varieties. There were findings of 3 groups statistically different (Table 3). Almond varieties showed remarkable differences in fibre contend. This ranged between 5.108% in 'Bonita S. Brás' to 11.788% in 'Parada'.

Our observations and discussions with the growers revealed that 'Parada', 'Casa Nova' and 'Marcelina Grada' are the preferred varieties, that had kernel shape broad, broad and extremely broad, and nut shape cordate, oblong and oblong, respectively.

Results of this study reflected a diverse germplasm of hard-shelled almonds in Trás-os-Montes region. Almost, in all varieties analysed the nutritional composition (proteins, lipids and fibres) presented superior results that are refereed by Kader (1996).

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