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Industrial characteristics of Spanish native almond cultivars and their interest for breeding programs

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Abstract. The displacement of almond orchards towards inland regions of Spain with high risk of spring frost fostered the use of self-compatible late-flowering varieties, adapted to these new areas. This fact is causing a progressive reduction of Spanish native, early flowering and self-incompatible local cultivars, many of them at risk of extinction or already extinct. Native varieties were selected over the years for their adaptation to the warm Mediterranean climate conditions and their high organoleptic quality. In addition, traditional confectionery products are based on particular characteristics of these cultivars. The first results on the industrial aptitude of these native cultivars are reported. It is outstanding the absence of cultivars with a high toasting aptitude and those with a broad shape.

Keywords. Almond – Germplasm – Characterization – Quality.

Caractérisation industrielle des collections espagnoles autochtones d'amandier et son intérêt pour les programmes d'améliorèrent génétique

Résumé. *Le déplacement de l'amandier jusqu'à zones intériences, avec le risque de gelées de printemps, ont favorisé l'utilisation des variétés auto-compatibles et de floraison tardive, plus adaptées a ces zones. C'est la raison de réduction progressive des cultivars autochtones qui sont en risque d'extinction. Ces cultivars ont été sélectionnes au fil des ans par les agriculteurs pour son adaptation au climat méditerranéen chaud et par raison d'une bonne qualité organoleptique. Ils sont un ressource génétique a protéger pour les futures programmes d'améliorement. En plus, l'industrie traditionnelle est bien adaptée aux caractéristiques de ces variétés. Ont présente des résultats sur l'aptitude industrielle des cultivars espagnoles autochtones. Ont peut remarquer l'absence de variétés de bonne aptitude au grillage et aussi des variétés de forma arrondie.*

Mots-clés. *Amandier – Germoplasme – Caractérisation – Qualité.*

I – Introduction

Few decades ago, there were many almond cultivars in Spain (Felipe *et al*., 1984; Egea *et al*., 1985; Rivera *et al*., 1997; Ramos Carmona 1983; Salazar and Melgarejo, 2002; Vargas,, 1975). This was due to the traditional propagation system by seed. Those native cultivars share some characteristics like early blooming, floral self-incompatibility or drought tolerance, and many of them taste better than American cultivars. The displacement of new orchards towards inland regions of Spain with high risk of spring frost fostered the use of self-compatible late-flowering varieties, adapted to these new areas. This fact is causing a progressive reduction of Spanish native early flowering and self-incompatible local cultivars, many of them at risk of extinction or already extinct. The progressive reduction of Spanish native local almond cultivars is a handicap for the traditional industry. In fact, traditional confectionery products are based on particular characteristics of the kernel of these cul-

tivars that are few common in the new almond cultivars. Toasting aptitude, sugar coating performance or round shapes are unusual in many cultivars from ongoing Spanish breeding programs. These aptitudes could be recovered from old native cultivars and used in future crosses.

Industrial aptitude is related to some physical and chemical traits that are responsible for processing problems, like splitting, breakage, browning or irregular coating (Socias i Company *et al*., 2008; Romero *et al*., 2011). The European project SAFENUT (AGRI GEN RES action 068) was focused on the characterization of hazelnut and almond native cultivars. This project succeeded on recovering some cultivars from Greece, Slovenia and Italy (Socias i Company *et al*., 2011). Regarding Spain, this project focused only in a small set of cultivars from the Reference Germplasm Bank from CITA-Zaragoza which is not including many of the most relevant native Spanish cultivars, due to the inland placement of this collection. The aim of this work was the evaluation of physical traits and industrial aptitude of Spanish native almond cultivars from collections of CEBAS-CSIC of Murcia and IRTA of Constantí.

II – Materials and methods

Almond genotypes studied included 44 early flowering and self-incompatible native cultivars from CEBAS-CSIC Murcia and IRTA-Constantí cultivar collections (Table 1). Almond samples were taken in 2013 and 2014 harvests.

Physical parameters were: kernel weight, weight loses after skin removal, dimensions, shape, kernel strength and elasticity (INSTRON texture analyzer using 34 mm penetration probe at 1 mm. sec^{-1} rate), raw kernel taste, kernel defects and skin color (MINOLTA spectrophotometer Model M3500, using CIELAB color space). These parameters were used to score industrial aptitude by using IRTA's predictive models (not published). Industrial aptitudes were: raw almonds, blanched, sugar coated, toasted, slices and thin tablet products. Mean values and least significant differences were computed by using SAS/STAT software (r.6.03, Cary).

III – Results and discussion

Physical traits for each almond cultivar are summarized in Table 1. Industrial aptitudes, derived from physical traits, are described in Table 2. Prevailing Kernel shape was elongated. Only few cultivars are broad in shape (width-to-length ratio higher than 0.75), as 'Marcona' and it's group, 'Verd', 'Carreró' and 'Nano'. 'Marcona San Joy' is clearly different from Marcona's group. Almond skin aspect (light color and smooth surface) is adequate for raw consumption only in 'Atocha', 'Malagueña' and 'Nano', while most of the cultivars are less valued for this purpose. Regarding blanching aptitude, this is good for almost all the cultivars, except for 'Gabaix' and 'Asperilla' that show weight loss after blanching higher than 11% (Fig. 1).

Kernel strength range is quite broad, from 70 to 170 N. This parameter is highly correlated to splitting trend that is a negative attribute for hull kernel manipulation (Romero *et al*., 2011). 'Fournat', 'Marcona', 'Tio Martín', 'Garrigues' and 'Planeta Roja' can be considered as good cultivars for industrial manipulation, with less than 20% of splits on average. Regarding sugar coating aptitude, this is related to kernel integrity and smooth surface, that are higher in 'Atascada', 'Bonita', 'Fina del Alto', 'Fournat', Marcona's group, 'Planeta Roja', 'Rumbeta' and 'Verruga' (although this is too small for this purpose).

Toasting aptitude is only high in 'Desmayo Largueta' and its group. This is particularly relevant, since new almond releases from breeding programs are also few adapted to this purpose (Romero *et al*., 2011).

Table 1. Physical traits of Spanish native almond cultivars (years 2013 and 2014)

Cultivar	Length (mm)	Width (mm)	Thick (mm)	Width/ length	Creasing??? (%)	Toasting (%[c])	Skin color			Sweet
							L*	a*	b*	
1 Angones[a]	19.7	11.2	7.6	0.57	0.0	30.0	26.3	10.5	16.8	sweet
2 Asperilla[a]	24.1	13.0	7.1	0.54	17.0	30.0	26.0	9.1	16.3	sweet
3 Atascada[b]	24.6	12.9	8.3	0.52	81.3	6.7	29.0	10.3	17.6	slight
4 Atocha[ab]	27.8	13.6	8.2	0.49	5.5	2.5	32.9	10.1	19.6	slight
5 Avellanera[b]	25.9	15.3	8.2	0.59	0.0	5.0	26.6	9.0	15.0	sweet
6 Bonita[b]	22.3	12.7	7.8	0.57	0.0	0.0	30.2	9.4	18.5	sweet
7 Carreró[a]	19.1	14.3	6.8	0.75	27.8	5.0	25.1	7.9	13.6	sweet
8 Carretas[b]	21.4	11.9	8.5	0.56	0.0	10.0	25.7	8.1	13.6	sweet
9 Carriset[a]	–	–	–	–	–	0.0	29.7	9.8	19.6	–
10 CEBAS-1[b]	22.9	11.2	8.0	0.49	3.8	15.0	25.3	9.6	15.0	sweet
11 Colorada[b]	22.9	12.7	8.0	0.55	5.0	45.0	29.0	10.2	16.7	sweet
12 Del Cid[b]	20.3	13.5	7.9	0.66	10.0	30.0	27.1	9.2	14.9	sweet
13 DesmayoAD[b]	24.3	13.3	7.9	0.55	0.0	95.0	29.4	9.8	17.1	sweet
14 Desmayo Lorca[b]	23.6	13.6	8.0	0.58	0.0	100.0	27.8	9.4	15.0	sweet
15 Desmayo Largueta[ab]	25.2	14.0	8.3	0.55	0.0	90.0	26.3	9.0	14.4	sweet
16 Esperança Forta[a]	21.1	13.6	10.5	0.65	0.0	25.0	26.6	10.5	16.8	sweet
17 Fina del Alto[b]	23.9	13.8	8.4	0.57	7.5	5.0	28.6	10.5	17.2	sweet
18 Fournat[b]	30.4	17.6	8.7	0.58	27.9	40.0	27.7	11.0	16.0	sweet
19 Gabaix[a]	21.1	11.6	7.5	0.55	21.3	0.0	28.9	10.2	19.3	sweet
20 Garrigues[ab]	24.3	14.5	7.4	0.60	3.2	15.0	27.7	9.8	15.5	slight
21 J.Salazar[b]	17.9	12.2	7.3	0.68	5.0	5.0	29.8	9.5	18.2	slight
22 Jordi[b]	23.1	12.5	8.8	0.54	0.0	20.0	29.3	12.0	19.6	sweet
23 La Mona[b]	24.0	15.5	9.0	0.64	30.5	0.0	31.6	10.3	20.0	slight
24 Malagueña[b]	27.9	11.4	8.3	0.41	26.4	0.0	30.7	8.8	17.0	sweet
25 Marcona[ab]	19.7	15.5	9.0	0.79	0.0	2.5	29.0	9.1	15.7	sweet
26 Marcona AD[b]	20.3	15.2	9.2	0.75	0.0	5.0	27.7	9.1	14.9	sweet
27 Marcona Flota[b]	18.9	14.2	8.5	0.75	2.1	5.0	25.8	8.8	12.9	slight
28 Marcona San Joy[b]	20.7	13.6	8.9	0.65	0.0	20.0	28.8	9.8	17.4	sweet
29 Marquet[a]	22.6	15.6	10.7	0.69	0.0	0.0	26.4	9.7	14.9	–
30 Mena d'en Musté[a]	24.3	14.4	9.5	0.59	0.0	30.0	30.8	11.3	20.0	–
31 Mollar de Tarragona[a]	22.0	13.8	8.9	0.63	39.2	5.0	27.6	9.0	14.3	slight
32 Nano[a]	18.5	13.9	7.7	0.75	0.0	0.0	32.0	9.6	19.8	sweet
33 Pajarera[b]	22.8	16.2	7.9	0.71	96.6	0.0	31.3	9.1	18.1	slight
34 Pauet[a]	22.6	12.9	6.9	0.57	13.3	50.0	27.9	10.1	17.4	slight
35 Pep Juneda[a]	24.2	13.3	7.6	0.55	0.0	60.0	27.2	11.5	17.9	sweet
36 Peraleja[b]	25.7	12.2	7.7	0.47	24.6	0.0	28.1	10.8	18.1	sweet
37 Planeta Fina[b]	24.5	15.5	7.4	0.63	5.0	0.0	30.9	10.5	18.2	sweet
38 Planeta Roja[b]	24.5	14.5	7.4	0.59	0.0	0.0	30.7	10.4	18.1	sweet
39 Ramillete[ab]	28.1	13.2	7.3	0.47	4.7	12.5	28.2	9.5	16.0	sweet
40 Rof[a]	20.9	14.9	8.4	0.71	100.0	0.0	29.3	9.8	18.4	slight
41 Rumbeta[b]	26.9	16.1	7.9	0.60	30.7	0.0	33.7	10.3	21.8	slight
42 Tío Martín[b]	24.8	14.5	9.3	0.58	100.0	5.0	27.0	9.0	15.0	sweet
43 Verd[a]	18.8	14.9	7.8	0.79	29.5	5.0	23.6	9.5	14.2	slight
44 Verruga[b]	18.5	10.9	7.6	0.59	0.0	0.0	26.3	10.4	15.9	sweet
LSD[d]	5.03	2.74	1.86	0.009	17.5	12.0	4.54	2.10	5.59	–
Significance level	0.041	0.061	NS	0.007	<.0001	0.0005	0.001	0.006	0.010	–

[a]: IRTA's collection; [b]: CEBAS-MURCIA collection; [c]: full peeled % after toasting; [d]: least significant difference.

Table 2. Industrial aptitude of Spanish native almond cultivars (years 2013 and 2014)

Cultivar	Raw almonds	Blanched almonds	Sugar coating	Toasted almonds	Sliced almonds	Thin tablets
1 Angones[a]	low	mean	mean	mean	mean	high
2 Asperilla[a]	low	mean	mean	mean	low	mean
3 Atascada[b]	low	low	high	low	low	mean
4 Atocha[ab]	high	mean	mean	low	mean	low
5 Avellanera[b]	low	mean	mean	low	low	mean
6 Bonita[b]	low	high	high	low	high	high
7 Carreró[a]	low	mean	mean	low	low	high
8 Carretas[b]	low	mean	low	low	mean	high
9 Carriset[a]	low	–	–	low	–	–
10 CEBAS-1[b]	low	low	high	low	high	high
11 Colorada[b]	low	mean	mean	mean	mean	mean
12 Del Cid[b]	low	mean	mean	mean	low	high
13 DesmayoAD[b]	low	mean	mean	high	mean	mean
14 Desmayo Lorca[b]	low	mean	mean	high	mean	mean
15 Desmayo Largueta[ab]	low	mean	mean	high	mean	mean
16 Esperança Forta[a]	low	–	–	mean	low	–
17 Fina del Alto[b]	low	high	high	low	low	mean
18 Fournat[b]	low	high	high	mean	low	low
19 Gabaix[a]	low	mean	low	low	low	high
20 Garrigues[ab]	low	low	mean	low	low	mean
21 J.Salazar[b]	low	mean	low	low	low	high
22 Jordi[b]	low	low	low	low	mean	mean
23 La Mona[b]	mean	mean	mean	low	low	mean
24 Malagueña[b]	high	low	low	low	low	low
25 Marcona[ab]	low	high	high	low	mean	high
26 Marcona AD[b]	low	high	high	low	mean	high
27 Marcona Flota[b]	low	high	high	low	mean	high
28 Marcona San Joy[b]	low	high	high	low	mean	high
29 Marquet[a]	low	low	low	low	low	low
30 Mena d'en Musté[a]	mean	–	–	mean	–	–
31 Mollar de Tarragona[a]	low	low	low	low	low	mean
32 Nano[a]	high	mean	mean	low	mean	mean
33 Pajarera[b]	mean	mean	mean	mean	low	mean
34 Pauet[a]	low	low	mean	mean	low	high
35 Pep Juneda[a]	low	mean	mean	low	mean	mean
36 Peraleja[b]	low	mean	mean	low	low	mean
37 Planeta Fina[b]	mean	high	mean	low	low	mean
38 Planeta Roja[b]	mean	low	high	low	low	mean
39 Ramillete[ab]	low	mean	low	low	low	low
40 Rof[a]	low	low	low	low	low	low
41 Rumbeta[b]	mean	high	high	low	low	low
42 Tío Martín[b]	low	low	mean	low	low	mean
43 Verd[a]	low	mean	low	low	low	mean
44 Verruga[b]	low	mean	high	low	mean	high

[a]: IRTA's collection; [b]: CEBAS-MURCIA collection.

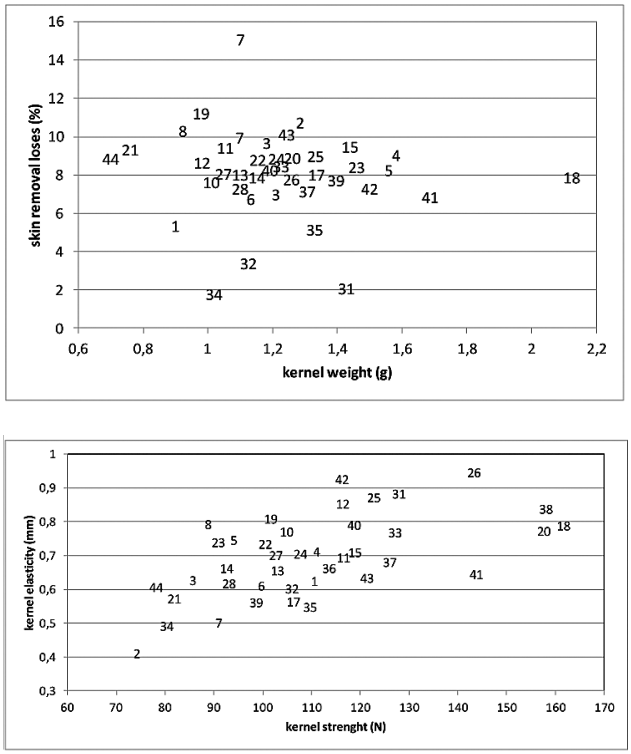

Fig. 1. Left: Kernel weight and loses after skin removing. Right: Textural properties of the almond cultivars (coded by numbers from table 1).

IV – Conclusions

Results showed the wide diversity of this almond native germplasm for industrial purposes. Some cultivars have interesting industrial traits that can be included in future breeding programs. Interestingly, none of the studied cultivars showed a kernel shape wider than 'Marcona' and only 'Desmayo Largueta' shows a high aptitude for toasting. This means that confectionery industry will demand these characteristics in future releases from future breeding programs, in order to reduce dependence on such traditional cultivars. More studies are required on this set of native cultivars, including nutritional characteristics that are related to complementary industrial properties.

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