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Some physical properties in nut and kernel of two almond varieties (‘Marcona’ and ‘Tuono’) grown in Northern Morocco

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Abstract. Cultivated almonds (Prunus dulcis [Mill.] D.A. Webb) are the second fruit culture in importance after olive trees in Morocco. The present work was carried out to evaluate some physical properties in nut and kernel of two almond varieties (‘Marcona’ and ‘Tuono’) widely grown in northern Morocco. 30 fruits were collected in three marked almond trees randomly around the canopy between August, 15 and September, 10 of the 2014 season in three different sites namely Aknoul (Taza), Bni Hadifa (Al Hoceima) and Tahar Souk (Taounate). ANOVA analyses indicated that environmental effect accounted for low variation percentages for most of studied traits except nut length and kernel thickness where it explained half of variation. Genotypic effect was more important in describing variation in the majority of characters. Mean comparison revealed that no significant differences were encountered among sites for nut thickness, sphericity and kernel weight and volume. For the others traits, Tahar Souk showed the lowest values. Between varieties, ‘Marcona’ presented higher values for most of characters except for length and shelling percentage.

Keywords. Prunus dulcis – Nuts – Kernels – Physical properties – Northern Morocco.

Quelques caractères physiques de l’amande et l’amandon chez deux variétés d’amandier (‘Marcona’ et ‘Tuono’) cultivées au nord du Maroc


I – Introduction

The almond (Prunus dulcis [Miller] DA Webb) is a widely grown fruit tree throughout the world. It is a major tree nut grown in areas of Mediterranean climate. In Morocco, almond is the second fruit culture in importance after olive trees in Morocco. It is grown in several regions from north to south, under different environmental conditions, mostly on non-irrigated lands (Kodad et al., 2015). The total almond national acreage is about 146.100 ha. Taza-Al Hoceima-Taounate region accounted for more than 37% of total cultivated area and for more than 18% of total production (Ministry of Agri-
In this region, almond trees are conducted following the traditional system where one or more environmental requirements are limiting including water during the growing season, soil depth, and nutrient availability (Mahhou and Dennis, 1992). At present, harvesting and handling of almond fruits carried out manually in the region. For optimum performance of threshing, conveying, sorting, storing and other processes of almond nuts and kernels, their physical and mechanical properties must be known (Mirzabe et al., 2013). Previous studies on physical traits in almonds were undertaken in Turkey (Kalyoncu, 1990; Aydin, 2003), Iran (Mirzabe et al., 2013), Australia (Zheng and Fielke, 2014) and Spain (Valverde et al., 2005). Kodad et al. (2015) studied physical fruit traits in almond local populations in northern and central Morocco. This work describes a comparative study of some physical properties of nuts and kernels in two almond varieties (‘Marcona’ and ‘Tuono’) from three representative sites of Taza-Al Hoceima-Taounate region (northern Morocco).

II – Materials and methods

This study was carried out in three sites of northern Morocco (Fig. 1), namely Aknoul (60 km from Taza, 34°39’0″ N, 3°52’0″ W), Bni Hadifa (50 km from Al Hoceima, 35°1’22″ N, 4°8’27″ W), and Tahar Souk (50 km from Taounate, 35°1’22″ N, 4°8’27″ W). Plant material consisted on two almond varieties (‘Marcona’ and ‘Tuono’) widely grown in northern Morocco.

Before harvest, three individual trees were selected in each site between August, 15 and September, 10 of the 2014 season. A sample of 30 fruits was collected randomly from the marked plants at maturity, when fruit mesocarp was fully dried and split along the fruit suture and peduncle abscission was complete.
After harvesting, all nuts were cleaned to remove foreign matter such as soil and stones, as well as immature fruit. For each individual almond nut, three main dimensions (Fig. 2), namely length (L), width (W), and thickness (T) were measured. For measuring principal dimensions of the kernel, almond nut was broken; then length (L), width (W) and thickness (T) of the kernel were measured. For all measurements, a digital caliper with accuracy of 0.01 mm was used. Nut and kernel mass was measured with an electronic balance of 0.001 g sensitivity.

![Fig. 2. Almond size parameters: L = length; W = width; T = thickness (Zheng and Fielke, 2014)](image)

The geometric mean diameter (Dg) and sphericity (Φ) were calculated by using the following equations (Mohsenin, 1970): 
\[ Dg = (LWT)^{1/3} \]  
\[ Φ = \left(\frac{LWT}{L}\right)^{1/3} \times 100/L, \] 
respectively. The volume (V) were calculated as follow (Mirzabe et al., 2013): 
\[ V = \left(\frac{π \times Dg^3}{6}\right). \] 
Combined analyses of variance and Duncan’s test were performed for measured and calculated parameters by using the SAS program (SAS, 2004).

III – Results and discussion

Results from the combined analyses of variance for almond nuts (Table 1) showed that site affected at a lesser extent the variability for the majority of characters except for length where it explained the half and it was not significant for some parameters such as thickness and sphericity. In contrast, variety effect was very significant and predominant accounting for more 75% of variability for most characters. Concerning almond kernels (Table 1), the same picture was reflected. In fact, site effect had a lower influence except for thickness and shelling percentage; while variety effect was significant for all traits and explained more than 70% of total variation. Site by variety interaction was of a lower extent and only significant in kernel characters.

Mean comparison among sites (Table 2) revealed that, for almond nuts, Aknoul and Bni Hadifa showed higher values for unit mass (3.88 and 4.40 g, respectively), length (30.61 and 32.04 mm, respectively), width (23.58 and 24.02 mm, respectively), geometric mean diameter (22.06 and 22.85 mm, respectively) and volume (5314 and 6258 mm³, respectively). For the rest of traits, no significant differences were obtained. For almond kernels, Tahar Souk presented the highest value for thickness (7.38 mm), sphericity (61.61%) and shelling percentage (30.18%) while it had a lower score for length and width. For the remaining traits, no significant differences were encountered.

Mean comparison between varieties (Table 3) demonstrated the superiority of ‘Marcona’ for the majority of characters in nuts and kernels except for length where ‘Tuono’ presented higher values (31.33 mm in nut and 22.34 in kernel). ‘Tuono’ was also superior to ‘Marcona’ in shelling percentage (28.69%).
Our results are in concordance with those obtained by El-Amrani et al. (2012) in Al Hoceima region. In fact, most of the studied characters were under genetic dependency. It has been demonstrated that nut mass and dimensions were controlled genetically (Kodad et al., 2011). Kernel mass is determined by genetic additive effects (Spiegel-Roy et al., 1981), with a heritability of 0.64 (Kester et al., 1977). Almond shells are generally characterized by their hardness and shelling percentage. Hard shells can reduce the proportion of nut meats recovered after shelling if adequate equipment is not utilized (Socias i Company et al., 2008). In our work, ‘Marcona’ presented a very hard shell in comparison to ‘Tuono’. In a study with local populations of almonds carried out in northern and central Morocco, Kodad et al. (2015) reported that all genotypes produced a hard to very hard shells. It has been noticed that with this kernel protection the nuts can be stored for a long time if not exposed to sunlight due to the fact that intact hard shells protect kernels from both insect damage and deterioration from molds. Kernel size is commercially important, as larger sizes are generally better valued (Socias I Company et al., 2008). In our work, ‘Marcona’ presented a very hard shell in comparison to ‘Tuono’. In a study with local populations of almonds carried out in northern and central Morocco, Kodad et al. (2015) reported that all genotypes produced a hard to very hard shells. It has been noticed that with this kernel protection the nuts can be stored for a long time if not exposed to sunlight due to the fact that intact hard shells protect kernels from both insect damage and deterioration from molds. Kernel size is commercially important, as larger sizes are generally better valued (Socias I Company et al., 2008). 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### Table 2. Mean values of sites for unit mass, length (L), width (W), thickness (T), geometric mean diameter (Dg), sphericity (F), volume (V) and shelling percentage (SP) of almond nuts and kernels. Means for each character followed by the same letter are not significantly different at P < 0.05

<table>
<thead>
<tr>
<th>Sites</th>
<th>Mass (g)</th>
<th>L (mm)</th>
<th>W (mm)</th>
<th>T (mm)</th>
<th>Dg (mm)</th>
<th>F (%)</th>
<th>Φ (mm³)</th>
<th>SP (%)</th>
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<tbody>
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<td><strong>Nuts</strong></td>
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<td>14.96 a</td>
<td>22.06 a</td>
<td>72.13 a</td>
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<tr>
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<td>32.04 a</td>
<td>24.02 a</td>
<td>15.60 a</td>
<td>22.85 a</td>
<td>71.70 a</td>
<td>6258 a</td>
<td></td>
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<tr>
<td>Tahar Souk</td>
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<td>28.43 c</td>
<td>20.91 b</td>
<td>15.13 a</td>
<td>20.76 b</td>
<td>73.14 a</td>
<td>4740 b</td>
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<td>Aknoul</td>
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<td>21.89 a</td>
<td>14.19 a</td>
<td>5.95 c</td>
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<td>23.39 b</td>
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<td>12.85 b</td>
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<td>12.39 ab</td>
<td>61.61 a</td>
<td>1000 a</td>
<td>30.18 a</td>
</tr>
</tbody>
</table>

### Table 3. Mean values of varieties for unit mass, length (L), width (W), thickness (T), geometric mean diameter (Dg), sphericity (F), volume (V) and shelling percentage (SP) of almond nuts and kernels. Means for each character followed by the same letter are not significantly different at P < 0.05

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<th>W (mm)</th>
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<th>F (%)</th>
<th>Φ (mm³)</th>
<th>SP (%)</th>
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<tr>
<td><strong>Nuts</strong></td>
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<tr>
<td>‘Marcona’</td>
<td>4.63 a</td>
<td>29.39 b</td>
<td>24.88 a</td>
<td>16.66 a</td>
<td>23.01 a</td>
<td>78.28 a</td>
<td>6412 a</td>
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<tr>
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<tr>
<td>‘Marcona’</td>
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<td>15.28 a</td>
<td>7.16 a</td>
<td>13.09 a</td>
<td>63.68 a</td>
<td>1174 a</td>
<td>21.95 b</td>
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<tr>
<td>‘Tuono’</td>
<td>0.83 b</td>
<td>22.34 a</td>
<td>12.22 b</td>
<td>6.31 b</td>
<td>11.96 b</td>
<td>53.64 b</td>
<td>903 b</td>
<td>28.69 a</td>
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</table>
IV – Conclusions

It can be concluded that because of narrow distances between the three sites of this study, climatic conditions may not vary for a large degree resulting in a lesser effect on physical properties of almond nuts and kernels in our region. In contrast, the origin of the two studied varieties ‘Marcona’ (Spain) and ‘Tuono’ (Italy), which affect strongly their genetic pool, could be the reason for major differences between these two varieties for all studied traits. Furthermore, ‘Marcona’ was clearly superior for most of parameters confirming its large use in traditional and modern almond systems in Morocco.

References


