



Biochemical and biometrics characterization of five varieties of *Pistacia vera* L. grown in Maoussa experimental station (northwest of Algeria)

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ABSTRACT

Both biometric behavior study and fruit biochemical analysis of five varieties of Syrian *Pistacia vera* introduced in Algeria in 1998 and raised in semi-arid bioclimatic stage (common Maoussa, Mascara, Algeria) led to a qualitative comparison. Based on the pistachio descriptor criteria established by the International Plant Genetic Resources Institute in 1997, characterization and descriptor of female varieties of pistachio were performed. The obtained results allow the better choice of species breeding in semi-arid zone of sandy clay soil structure under an average annual rainfall of 385 mm. The best fruit biometric and biochemical characteristics increase as follows: Achouri, Neb-djemel, Bayadhi, Batouri and Adjmi.

Keywords: *Pistacia vera* L.; biometrics; fruit; kernel; varieties

INTRODUCTION

Pistachio (*Pistacia vera* L.) the only edible crop among the 11 species of the genus *Pistacia* [1] is a dioecious tree belonging to the family *Anacardiaceae* (cashew family), order Sapindales [2, 3].

It's difficult to determine the original center of Pistachio. The majority of *Pistacia* stands and crops are found in a region between 30 ° and 40 ° parallel north, the Mediterranean and the Himalayan foothills [4, 5, 6, 7, 8]. According to Fasihi Harandi and Ghaffari, [9], the *Pistacia veraspecies* is native to Central Asia.

Pistachio trees grow naturally in arid regions of Asia (Middle East) and Africa (Maghreb) which characterized by hot, dry summers and moderately cold winters. They are present in Australia, few countries in America (United States and Mexico) and the Mediterranean Europe [10]. This tree is more tolerant of poor soils and does best on those that are sandy, clay, relatively deep, well drained and calcareous [11]. Iran and the USA are the leading countries in pistachio production in the world (approximately 65% of the world production) followed by Turkey, Syria and China [12].

The pistachio (*Pistacia vera* L.) is an interesting species by its ecological characteristics. It was introduced to Algeria in 1970 in the semi-arid bioclimatic stage for nut production and to engaging in agroforestry. The few successful plantations cover only 400 hectares.

The limited interest to this species in spite to its ecological and economic properties is justified by the lack of agronomists' interest in the selection of varieties adapted to the environmental Algerian conditions. The main constraints to the expansion of *Pistacia vera* area are technical, mostly bad choice of varieties and a lack mastery of grafting.

The purpose of this work is to characterize each variety in order to facilitate its identification and to orient the choice of the graft during the grafting operation.

EXPERIMENTAL SECTION

The description was conducted on plants of the experimental farm of TIFTV in the pistachio orchard where five Syrian varieties (Achouri, Neb-djemel, Bayadhi, Adjmi and Batouri) were planted in 1998 with a planting density of 400 plants per hectare on alluvial soil type and which were tested based to the descriptor of this species from the International Institute of Genetic Plant Resources of Rome [13]. This orchard characterized climate is Mediterranean type belonging to the semi-arid bioclimatic stage according to fresh winter Emberger, he was designed for the production of seed for the development of plants rootstocks. The measures relating to dimensions of the fruit and almond are carried out on a sample of 7 times 20 fruits taken at random from trees. For leaves, a sample of 5 x 20 sheets was taken from five trees of each variety. The number of the five varieties analyzed for their morphological and biometric parameters are 20; and about the biochemical analysis of fruit aspect, 8 parameters have been retained and all recapitulated in Appendix 1 with the observed and analyzed sample sizes.

Concerning the biochemical analyzes, the total sugars were determined by the Dubois method, ash and organic matter by burning at 750 °C, the moisture by drying at 105 °C, the protein by the Kjeldahl method and the lipids by the method of Soxhlet.

The results have been analyzed focused on the study of the variance with comparison of means with the Newman-Keuls test (Fisher test) at a probability level of 5% using XLSTAT version 2015 program and the analysis of the average by principal components analysis of the various characters studied by the Statistica software.

RESULTS AND DISCUSSION

3.1. The tree habit

The habit provides information on the natural distribution of branches and main ramifications, secondary and tertiary, it can be: erected (1), semi erected (2), spread (3) or falling (4) (Figure 1) [14]. Based on the figure below of pistachio descriptor.

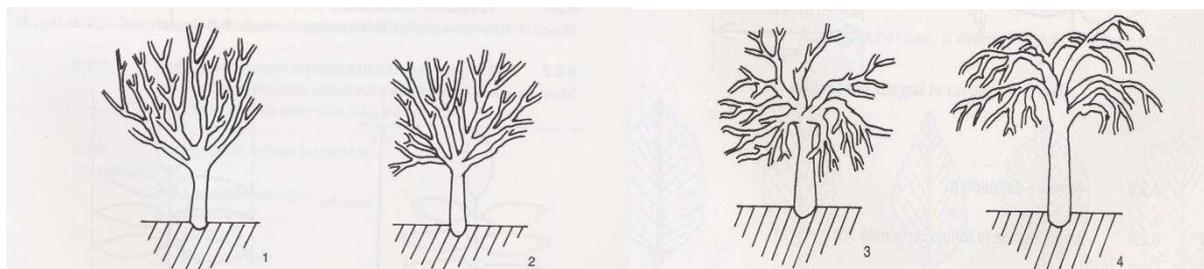


Figure 1. Habit of the tree (IPGRI, 1997)

From the result, Achouri and Bayadhi varieties have erect habit; Neb-Djemel and Batouri port are spread, while Adjmi is semi-erect. Habits of these varieties introduced in Algeria are quite similar to other varieties like Mateur, Kerman, Uzum, Kirmizi and Meknassy [15] and different to Lybie rouge and Ohadi, uncultivated varieties in Algeria which have falling habit [14]. Erected and semi erected habits seems the most interesting because they are suitable to the agroforestry practice.

3.2. The vigor

The best results in terms of diameter were recorded for Achouri and Neb-Djemel varieties 12.19 and 10.54 cm respectively. The diameters of the other three varieties remain substantially the same with only 10 cm as shown in Figure 2. The analysis of variance revealed no significant difference between varieties.

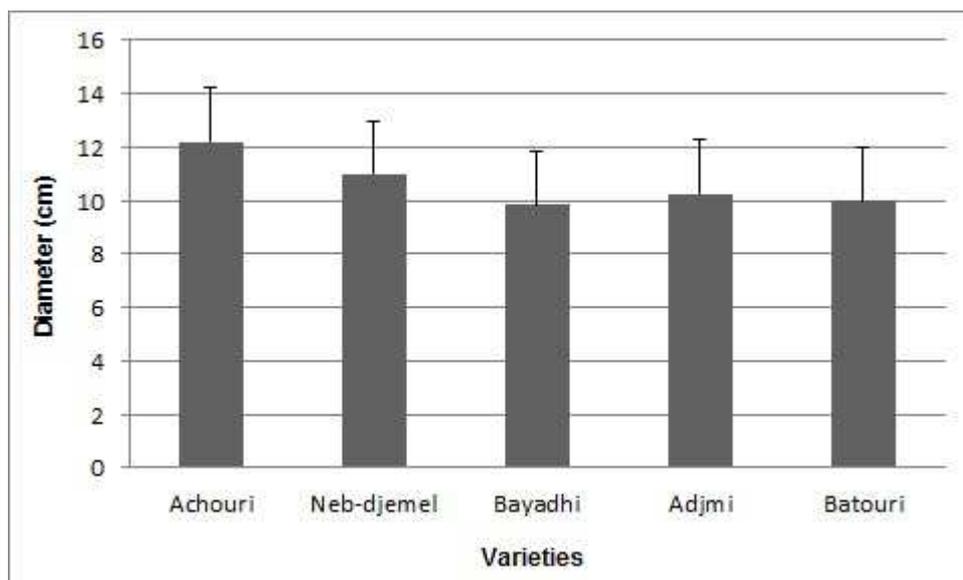


Figure 2. The trunks diameter variation in of five varieties of pistachio

3.3. The leaf

The leaf Neb-Djemel variety has the largest value of length (19.95 cm), while the Bayadhi variety records the lowest (16.02 cm). For the width of the leaf, the Batouri variety obtains the largest value, 18.46 cm; while Bayadhi variety had the lowest, 16.98 cm (Figure 3).

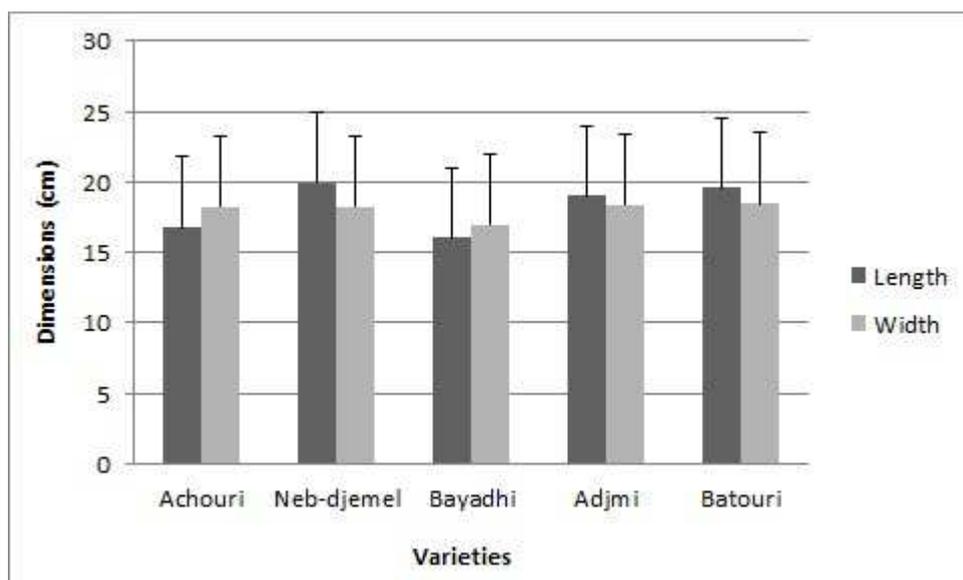


Figure 3. Length and width of the leaves of five varieties of pistachio

The analysis of variance revealed that there were statistically an important significant differences between the leaf length of different varieties of $F_{cal} = 33.27$. The varieties differ significantly in the length of their leaves while ANOVA showed significant differences between the leaf width of different varieties of $2.30 = F_{cal}$.

3.4. The terminal leaflet

The terminal leaflet is an interesting parameter to differentiate between the five varieties, which are confirmed by the results obtained and summarized in Figure 4.

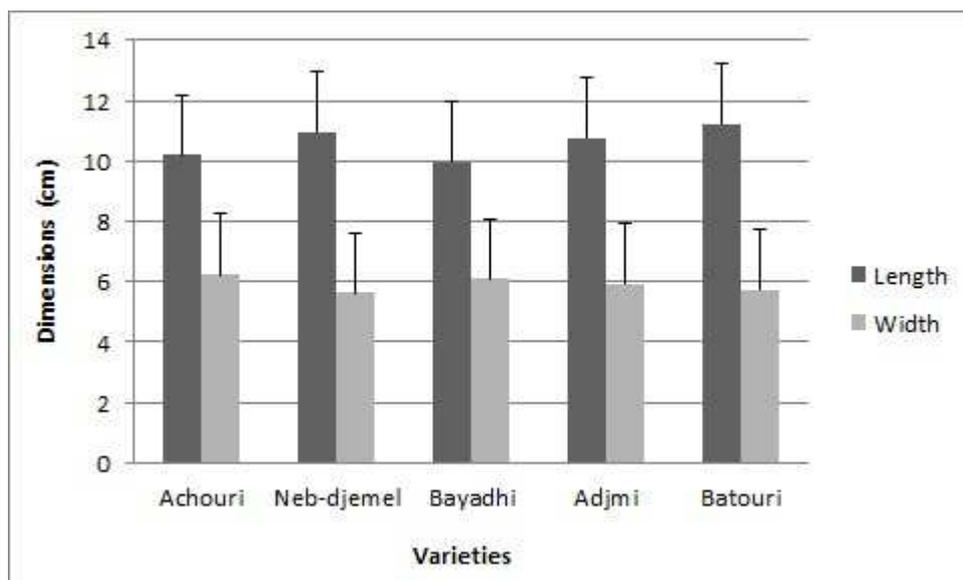


Figure 4. Length and width of the terminal leaflet variation of five varieties of pistachio

The Batouri variety has the highest length value (11.24 cm), while Bayadhi variety recorded the lowest (9.97 cm). Regarding to the width, the Achouri variety has the largest value (6.23 cm); while Neb-Djemel variety revealed the lowest (5.63 cm). The obtained Data show a significant difference between the length and width of the terminal leaflet of different varieties.

3.5. The fruit

This is a decisive parameter in the selection of varieties in terms of economic importance as shown in Figure 5 below.

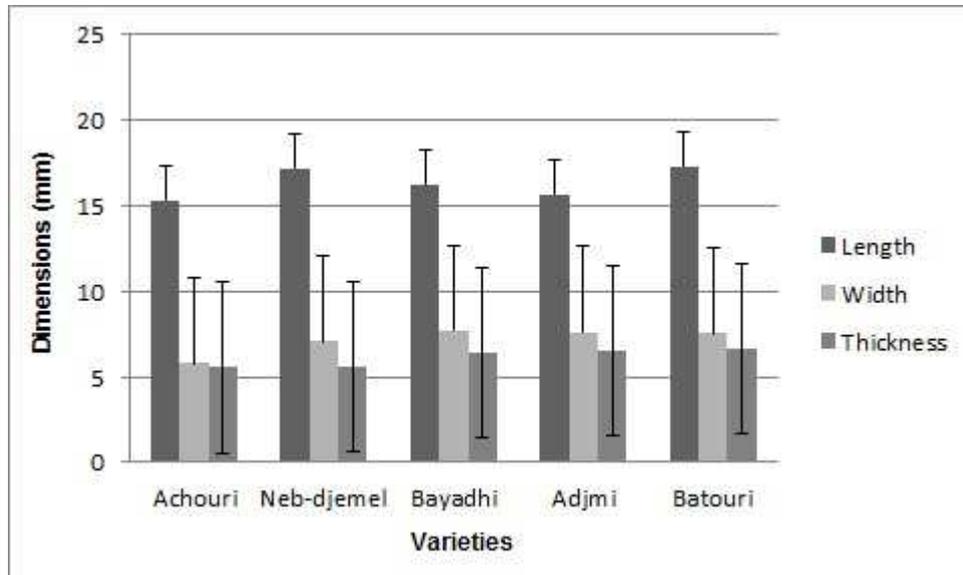


Figure 5. Fruit length, width and thickness of five of five varieties of pistachio

The smaller dimensions were showed in the fruit of Achouri variety, when Batouri variety gets the greatest values 17.31 mm in length and 6.63 mm in thick. These results are similar to those of Mendes *et al.* [16]. Who showed that this variety which in grown a Portuguese orchard has a very important length and thickness compared to other studied varieties. The Bayadhi variety gives wider fruits (7.7mm). The analysis of variance of the three-dimensions revealed a highly significant difference between varieties.

3.5.1. Thickness / length ratio of the fruit (T/L)

The ratio thickness / length of the fruit is an interesting indicator for economic selection. The Adjmi variety presents the highest ratio E / L (0.41) while Neb-Djemel variety showed the lowest (0.32) (Figure 6). Mendes *et al.* [16] have obtained similar results with a ratio of 0.60 for Adjmi variety and 0.58 for Batouri variety.

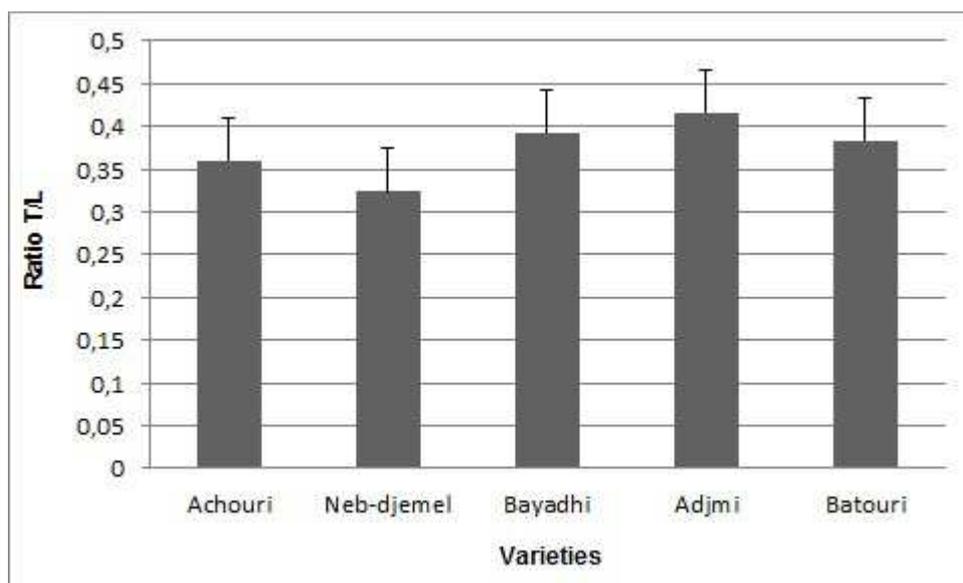


Figure 6. Thickness / fruit length ratio of five of five varieties of pistachio

3.6. Kernel

The obtained results (Figure 7) revealed that Batouri variety gets the highest dimensions, 12.61 mm for length and 4.04mm for width. The kernel of Adjmi variety has the greatest thickness, 4.01mm, that Achouri variety records the lowest length values 15.32 mm and thickness 3 mm; while the kernel of Neb-Djemel variety reaches only 2.77mm. The results obtained by Mendes *et al.* [16] on the length of the kernel for Batouri, Adjmi and Achouri varieties are respectively 16.82, 16.24 and 15.59 mm, superior to our results.

Regarding the thickness, it was 8.4 mm for Adjmi variety, 8.38 mm for Batouri variety and 7.7 mm for Achouri variety, higher to our results. These dimension differences can be explained either by the age of the trees or the soil and climatic conditions of the planting zone. The analysis of variance of the three dimensions of the kernel of the five varieties (length, width and thickness) shows a highly significant difference and can retain this parameter as criteria for selection of varieties.

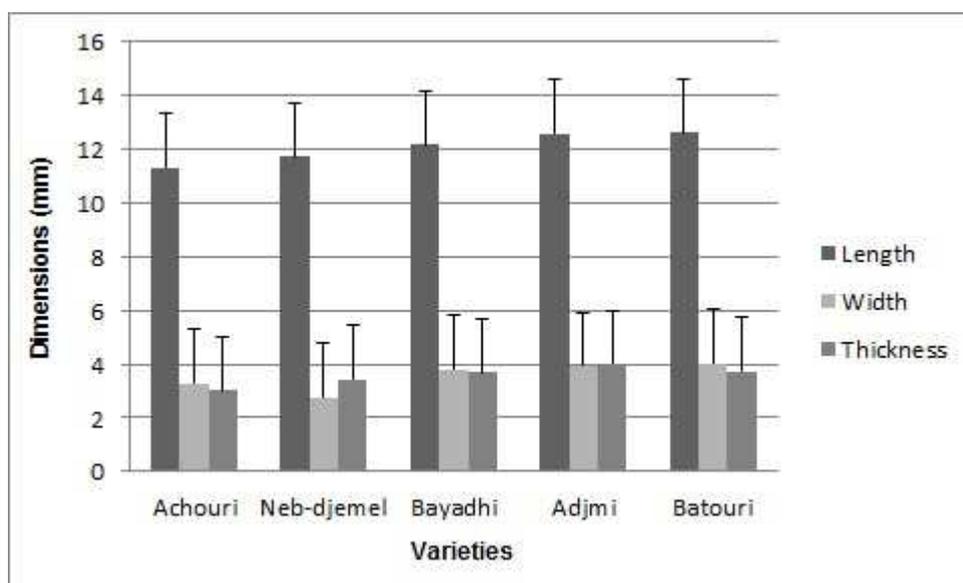


Figure 7. Kernel length, width and thickness of five varieties of pistachio

3.6.1. Thickness/length ratio of kernels

The exploitation of measurements carried out and returnable in Figure 8 puts Adjmi variety in the first position with a higher T/L ratio, 0.31. In contrary, the Achouri variety presents the lowest ratio, 0.26. Our results confirm the results of Mendes [16], which found that the Adjmi variety had the highest T/L ratio (0.52) and Achouri the lowest (0.49).

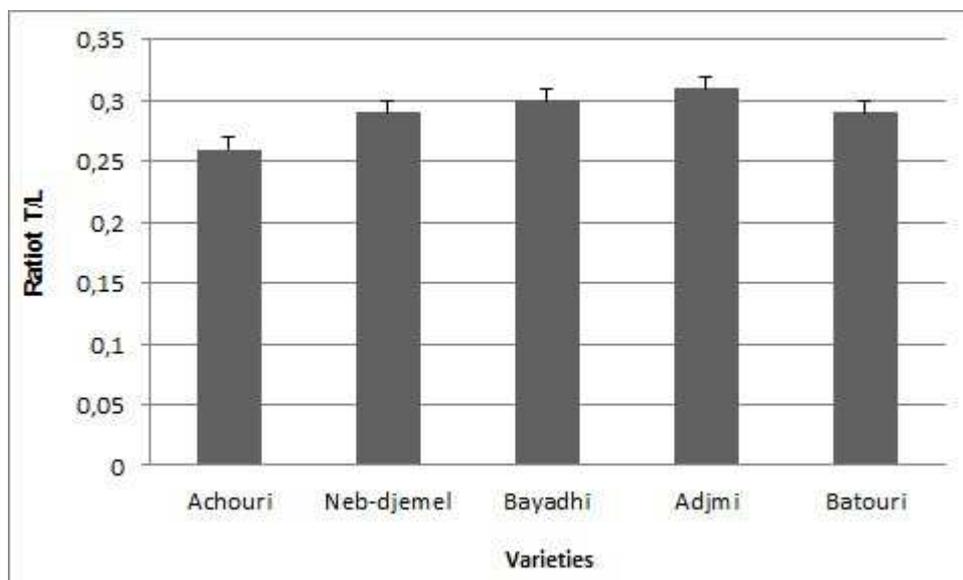


Figure 8. Thickness / kernel length ratio of the five varieties of pistachio

3.7. Dry weight of 100 fruits and 100 kernels

The dry weight of 100 almonds is another interesting parameter for comparison between varieties which Batouri variety gives the greater, 131.2 g, followed by Achouri variety (105.83 g), Adjmi variety (68.36 g) and Achouri variety only 50.97 g (Figure 9).

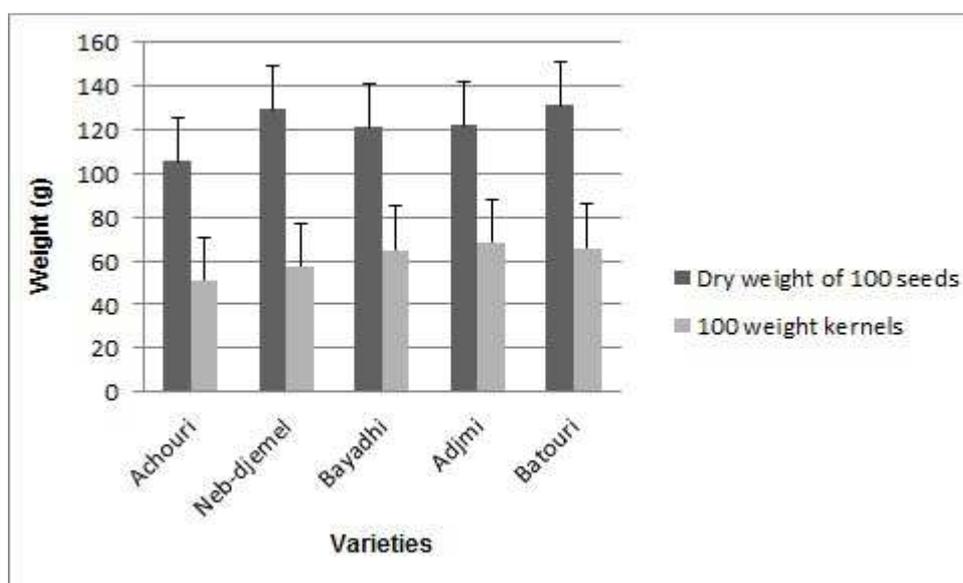


Figure 9. Dry weight of 100 fruits and 100 kernels of five varieties of pistachio

The analysis of variance of the two parameters revealed a highly significant difference between the samples which can use as criteria for comparing the five varieties.

3.8. Number of fruits in 100g

In terms of yield, the number of fruit per 100g is an interesting parameter and the results recapitulated in Figure 10 permit a comparison between the five varieties. The Achouri variety presents 95 fruits in 100g as highest value;

while Batouri variety gives the lowest number, 76. These values are closely related to the dimensions previously described namely length, width and diameter of the fruit. Bayadhi and Adjmi Varieties have respectively 83 and 82 seeds since they recorded the same dry weight of 100 fruits. The analysis of variance of three-dimension revealed a highly significant difference between varieties.

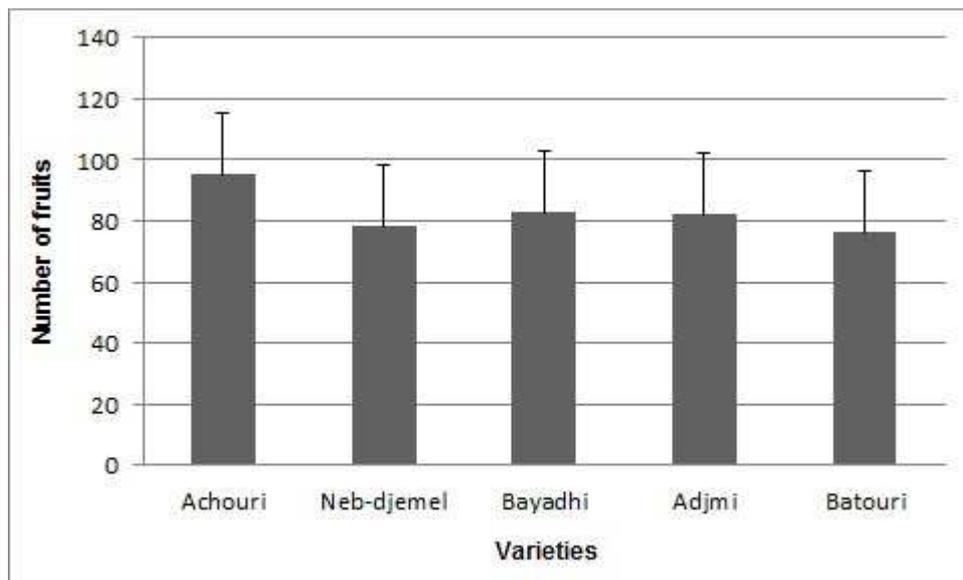


Figure 10. Fruit number in 100 g of five varieties of pistachio

3.9. Fruits dehiscence rate

The percentage of dehiscent fruits is a very important characteristic in the pistachio. It can vary depending on the varieties and among samples from the same variety (influence of genetic and environment factors) (Figure 11).

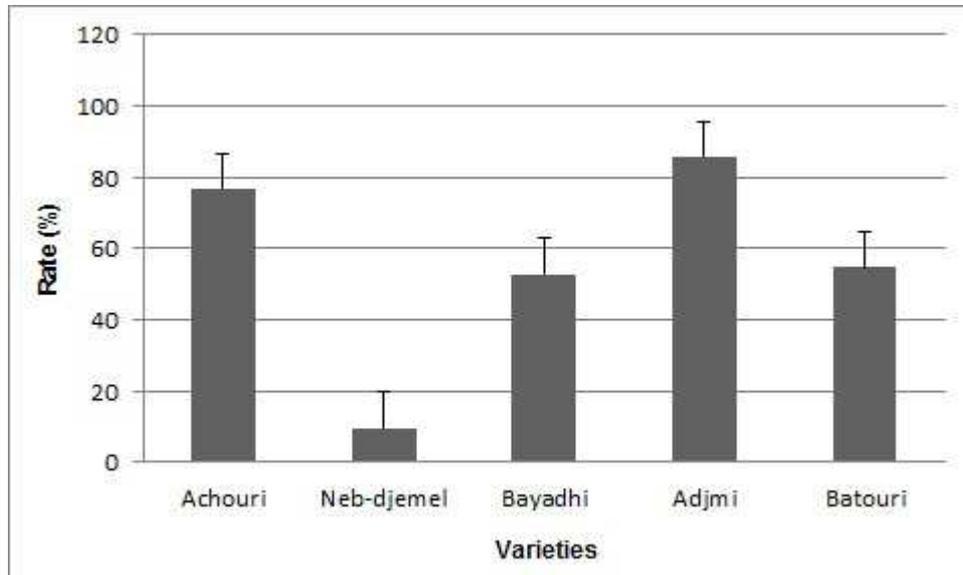


Figure 11. Rate of fruit dehiscence of five varieties of pistachio

Adjmi variety records the highest rate of fruit dehiscence 85.75%, followed by Achouri variety 76.75%. The Bayadhi and Batouri varieties register nearly the same rate 52.88 and 54.77% respectively. The Neb-Djemel variety comes in last place with a dehiscence rate of 9.62%. The results obtained by Oukabli [17] for three consecutive years show that the rate of dehiscence of Achouri, Batouri and Bayadhi varieties are respectively 68%, 60% and 57%. However in Portugal, Mendes *et al.* [16] register 43% in the rate of dehiscence for Batouri variety. Significant differences but confirm the same classification of these varieties. The results obtained by Oukabli [17] for three consecutive years show that the rate of dehiscence varieties Achouri, Batouri and Bayadhi are respectively 68%,

60% and 57%. This factor plays an important role in the marketing of pistachios; in fact many consumers appreciate the benefits of open pistachio nuts to those with closed shells.

The analysis of variance of this parameter shows a highly significant difference between varieties.

3.9. Productivity

Productivity gives information on yield per tree and is a useful parameter for the choice of the plant variety (Figure 12).

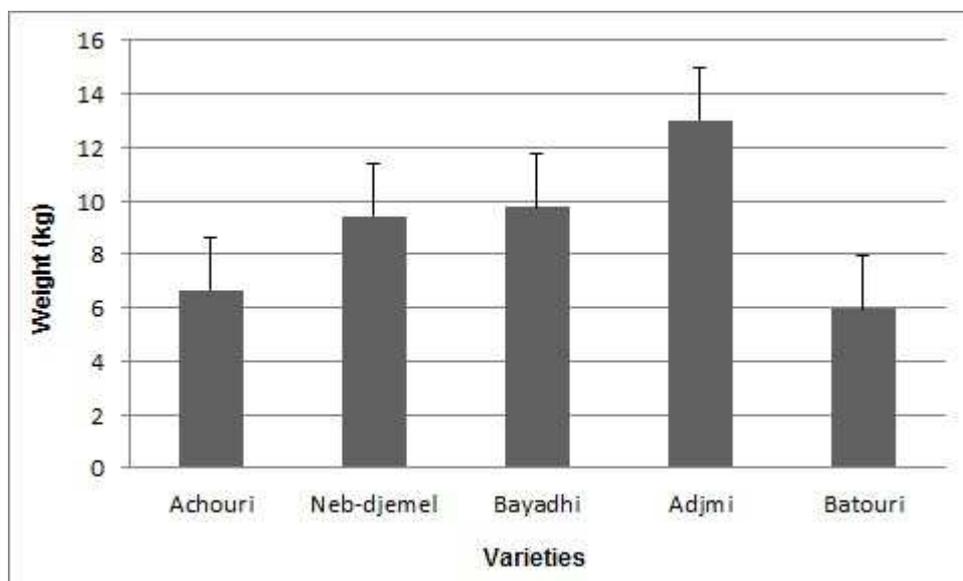


Figure 12. Fruit productivity by tree of five varieties of pistachio

The results show clearly that Adjmi variety is the most productive variety with 13 kg / tree. The least productive varieties are Achouri and Batouri with average of 6 kg / tree. Neb-Djemel and Bayadhi varieties produce 9 kg / tree.

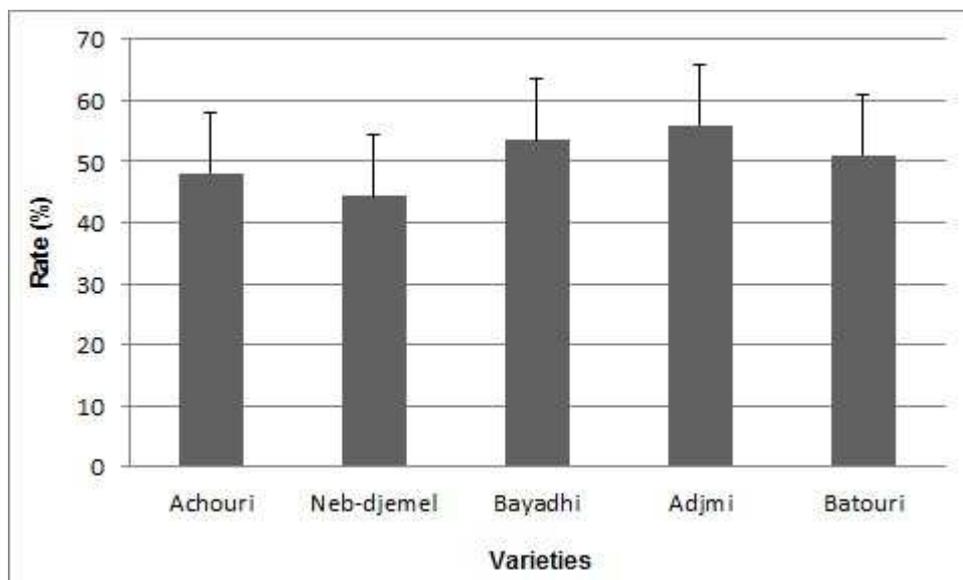


Figure 13. Ratio of Dry weight of kernels / Dry weight of fruits x100 of five varieties of pistachio

3.10. Kernels dry weight / dry weight x100 fruits

Almonds dry weight and dry weight fruit ratio gives idea on the economic profitability of the five varieties. The obtained and recapitulated measurements in Figure 13 show that Neb-Djemel variety has the lightest epicarp compared to other varieties. Indeed about 44% of the fruit weight is lost when it is commercialized without epicarp, in contrast to the Adjmi variety which has the heaviest epicarp (56% of the fruit weight). Mendes *et al.* [16]

emphasize 47.82% of epicarp rate of Batouri variety, fairly similar to our result (51%). The analysis of variance of this parameter shows a highly significant difference between the varieties, which can take it as classification criteria.

4. Biochemical Analysis

To refine comparison parameters, biochemical analysis of five varieties is essential. Table 2 summarizes the results of the biochemical analysis of fruits of the five studied varieties.

Table 2. Biochemical analysis results of the fruit of five varieties of pistachio

Varieties	Humidity %	O. M %	Ash %	Acidity %	Minerals %	Proteins %	Lipids %	Total sugars %
Achouri	3.65	97.82	2.18	1.48	0.39	5.61	32.51	10.91
Neb-djemel	5.10	96.57	3.43	0.68	0.46	8.50	22.50	8.66
Bayadhi	3.94	98.41	1.59	1.56	0.44	4.93	26.13	9.12
Adjmi	5.43	97.52	2.48	1.04	0.45	6.12	31.78	6.65
Batouri	4.19	97.60	2.40	1.40	0.53	12.41	33.11	8.13

The pistachio seeds of five varieties shows high lipid content with over 30% for Achouri Adjmi and Batouri varieties while Neb-Djemel and Bayadhi varieties have rates of 22.5 and 26% respectively. Our results are lower to those found by Ghalem and Behassaini [18] and those indicate by USDA National Nutrient Database [19] in which are respectively 40% and 45%. While Agar *et al* [20] showed that the fat content of the Turkish varieties ranged from 48.55% to 58.50% and from 47.65 to 63.31% for Iranian varieties.

Regarding protein, Batouri variety had the highest rate of 12.41%, Achouri and Bayadhi varieties recorded the lowest rate with 5.61 and 4.93% respectively. Turkish Uzun variety contains 27.7% of protein [21] and 20.5% for Idaho and Kerman, Iranian varieties [22]. According to USDA National Nutrient Database [19], the protein rate is 20%. For organic matter, minerals and total sugars, the results are rather close and are not parameters of differentiation. The humidity rates of Syrian and Iranian varieties were respectively 4.5% and 3.5%, while the ash content are 2.41% and 2.81%. For minerals, the amount of potassium of the Iranian varieties is five times more than the Syrian varieties. In contrast the sodium content of the Syrian varieties is seven times more than the Iranian varieties. But about the calcium, the varieties of the two different origins present nearly the same proportion [22].

5. Synthesis of the obtained results

The exploitation of the obtained results permits to retain some important information which facilitates the selection of varieties:

- The Achouri variety is the strongest with a trunk diameter of 12 cm;
- The fruit of Batouri variety has the longest and largest diameter;
- The fruit of Bayadhi variety is the widest;
- The almond of Batouri variety is the longest and widest;
- The fruit of Adjmi variety is the largest;
- The variety Batouri has recorded the highest weight of 100 fruits;
- The Adjmi variety showed the highest rate dehiscence;
- The Adjmi variety was the most productive, while Batouri variety was the least;
- The Adjmi variety scored the highest yield, while Neb-Djemel variety gives the lowest.

The matrix (Appendix 2) recapitulates all the biometric data and permit a ranking of the five varieties according to their qualities. Concerning the biochemical composition of the fruit, all studied varieties showed almost the same rate except fats, proteins and minerals contents.

The classification is done on the basis of the number of times that the variety has been ranked the first in the criteria comparison. The obtained results are summarized in Table 3.

Table 3. Comparison Matrix

VarietiesCharacters	Achouri	Adjmi	Batouri	Bayadhi	Neb-djemel
1 st place	4	7	6	3	2
2 nd place	4	3	2	6	6
3 rd place	0	6	9	4	4
4 th place	7	3	2	4	4
5 th place	6	2	2	4	5
Ranking	5	1	2	3	4

CONCLUSION

The obtained results permit to show significant differences between the five studied varieties in regard to their agronomic and commercial characteristics such as the vigor, the tree habit, productivity and fruit and almond characters.

The choice of the most adapted and effective pistachio varieties in terms of vigor and production in the study area are as follows: the first is the Adjimi variety followed by Batouri, Achouri, Bayadhi and the last is Neb-Djemel.

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Annex 1

	Parameters	Sample number
1.	Tree habit	25 Trees
2.	Vigor	25 Trees
3.	Leaf length	100 Leaves
4.	Leafwidth	100 Leaves
5.	Length of the terminal leaflet	100 Leaves
6.	Width of the terminal leaflet	100 Leaves
7.	Width of fruit	140 fruits
8.	Length of fruit	140 fruits
9.	Fruit diameter	140 fruits
10.	Thickness / length ratio of the fruit	140 fruits
11.	The kernel width	140 fruits
12.	The kernellength	140 fruits
13.	The kerneldiameter	140 fruits
14.	Thickness / length ratio of the kernel	140 fruits
15.	Dry weight of 100 fruits	7 x 100 fruits
16.	Weight of 100 kernels	7 x 100 amandes
17.	Fruit number in 100 g	7 x 100g
18.	% of dehiscence	7 x 100 fruits
19.	Productivity	25 trees
20.	Dry weight of kernels / Dry weight of fruits x100	
	Biochemical Analysis	
21.	Humidity	
22.	Organic Matter (O.M)	
23.	Ash	
24.	Minerals (Na, Ca, K)	
25.	Acidity	
26.	Proteins	
27.	Total Sugars	
28.	Lipids	

Annex 2

VarietiesCharacters	Achouri	Adjmi	Batouri	Bayadhi	Neb-djemel
Habit	1	2	3	1	3
Leaves	4	3	2	5	1
Vigor	1	3	4	5	2
Fruit	5	4	1	3	2
Diameter/ fruit length	4	1	3	2	5
Kernel	5	2	1	3	4
Diameter/ almond length	4	1	3	2	3
Dry weight of fruits	5	3	1	4	2
Dry weight of kernels	5	1	2	3	4
Production	4	1	5	2	3
Fruit number in 100g	1	3	5	2	4
Rate of fruit dehiscence	2	1	3	4	5
Dry weight of kernels / Dry weight of fruits x100	4	1	3	2	5
Humidity %	5	1	3	4	2
Organic Matter %	2	4	3	1	5
Ash %	4	2	3	5	1
Acidity %	2	4	3	1	5
Minerals %	5	3	1	4	2
Proteins %	4	3	1	5	2
Lipids %	2	5	1	3	4
Total Sugar %	1	5	4	2	3
Total	70	53	55	63	67