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Identification of promising apricot cultivars for fruit drying in Tunisia

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Abstract

Traditionally, the Tunisian apricot production is mainly consumed in fresh. Many studies were conducted on fresh apricots for several objectives such as conservation of biodiversity and varietal improvement. But, data about the drying ability of apricots are very limited. In order to select promising cultivars for drying, physico-chemical characteristics of fresh and dried fruit were studied for 10 apricot cultivars (local ones: "Ouardi", "Sayeb", "Amor Leuch", "Bayoudhi" and "Kasserine 2"; introduced ones: "Grilli", "85", "Precious", "Golden" and "Perlite") grown in conventional farming system. The apricots were treated with sulphurin enclosed chamber (1500 g/tons during 24h) and after, they were sun-dried in solar dryers. Important differences were noted between the studied cultivars for the majority of parameters. The fresh fruits varied in weight between 19.86g ("Perlite") and 73.07g ("Precious") and in size between 31 mm ("85") and 47.04 mm ("Precious"). The flesh firmness ranged between 19.07 ID ("Ouardi") and 47.65 ID ("Bayoudhi") and the flesh percentage varied between 89.55% ("85") and 95.69% (Golden). The lowest TSS was obtained in "85" (9.40 °Brix) and the highest value was registered for Sayeb (13.27 °Brix). For dried apricots, the highest values of contents of dried matter, carbohydrates and proteins and also energetic value were obtained in "Kasserine 2" (72.39%, 65.12%, 3.38% and 277.32 Kcal/100g, respectively). Likewise, "Sayeb", "Amor Leuch", "Golden", "Perlite" and "Precious" showed important and close percentages of dried matter (exceeding 66%), carbohydrates (near 60%), protein (3%) and energetic value (exceeding 250 Kcal/100g). In conclusion, 3 local apricot cultivars "Sayeb", "Amor Leuch" and "Kasserine 2" and the 3 introduced ones "Golden", "Perlite" and "Precious" could be chosen for dry apricot production in Tunisia.

1. Introduction

Apricot trees *(Prunus armeniaca* L.) are grown in many countries in the world. Turkey, Iran, Uzbekistan and Italy are the major apricot producers. The total world fresh apricot production was 3.839 million tons in 2018.Turkey is the leading country in the production of apricots (750 000 million tons in 2018) [1].

In Tunisia, the cultivation of the apricot tree is relatively old. It dates from the arrival of the Arabs in the 7th century [2]. The annualapricot production was around 37500 T and the area was about 9200 ha [3]. Kairouan region is the most important area in terms of occupied areas and apricot production (37% and 40% of the national area and production, respectively). Governorates of Gafsa (5035 T), Kasserine (4000 T), Beja (3000 T) and Gabes (1050 T) are also considered among the main apricot production areas in Tunisia [3]. The majority of the Tunisian apricot production is consumed in fresh.

Due to the short shelf life of fresh apricots, these are subjected to different preservation methods, the most common being canning or drying (open air sun drying, hot air drying, microwave drying or combined methods) [4]. Solar dryers used for agricultural product drying can be proved to be most useful device from energy conservation point of view that not only save energy but also saves a lot of time, occupying less area, improves product quality and personnel life style [5]. Dried fruits, as a consequence of concentration, have a higher total energy, nutrient density, fibre content, and often significantly greater antioxidant activity compared with fresh fruits [6].

In Tunisia, apricot drying trials began in the 1950s at the Kasserine experimental farm of INRAT, where a comparative study using a solar dryer and a dehydrator, during 2 successive years, allowed the marketing of dried apricots at interesting cost prices. This was considered for the farmers in the center of Tunisia, far from important markets, who have difficulties in selling their products [7]. However, these drying tests were not continued thereafter.

For this reason, and since 2013, the project "Promotion of sustainable agriculture and rural development in Tunisia" ("PAD") implemented by GIZ and the Ministry of Agriculture, Water Resources and Fisheries had among its objectives the sustainable improvement of the incomes of the rural population in the center-west of Tunisia by the improvement of apricot production and processing. For that, during the second phase of "PAD" ("PAD" II: 2016-2019), , the collaboration of the various actors was supported by this project in order to create new markets for the export of sun-dried apricots. It's about the promotion of agricultural value chain, oriented towards exportation of dried apricots.

2. Material and Methods

2.1. Plant material

In 2018, physico-chemical characterization studies of fruits (fresh and dried) of 5 local and 5 introduced apricot cultivars, grown in conventional farming system, were carried out in order to identify the promising cultivars for drying. These cultivars are cultivated in the center-west regions of Tunisia: Kairouan (35°40' latitude and 10°05' longitude) and Kasserine (35°17'latitude and 8°84' longitude)". The local cultivars were "Ouardi", "Sayeb", "Amor Leuch", "Bayoudhi" and "Kasserine 2" ["Kasserine 2"is the synonym of the French variety "Bergeron" [8]]. The introduced cultivars were: "Grilli", "85", "Precious", "Golden" and "Perlite" (Photo 1).

2.2. Physico-chemical characterization of fresh apricots

The physico-chemical characterization of fresh apricots was done according to the international descriptors of apricot [9-10] and to the studies of Lichou et *al.* [11]. Physical, chemical, sensorial and technological parameters of fruit as attractiveness, shape, size (weight and width), ground color of skin, color of flesh, over color, firmness, texture, juiciness, total soluble sugars, titratable acidity, weight of stone, etc. were studied. For that, 30 uniform, healthy and easily picked fruits per cultivar were randomly harvested and analyzed at the physiological maturity stage (ready-to-eat). Harvested date ranged between the end of May and the second week of June, depending on genotypes.

2.3. Sun drying process and physico-chemical and microbiological analysis of dried apricots

Sun drying trials of conventional apricots were done at the company "Linagro" (Enfidha-Sousse, Tunisia). Before drying, the apricots were treated with sulphur (1500 g /tons) in enclosed chamber for 24h. Then, they were sun-dried in solar dryers (with nets).

« Grilli »

« 85 »

« Precious »

« Golden »

« Perlite »

« Kasserine 2 »

« Ouardi »

« Sayeb »

Photo 1: Fruits of studied apricot (*Prunus armeniaca L.*) cultivars

The 1st drying lasted2 days and the 2nd drying lasted 5 to 6 days. These 2 drying periods were separated by the pitting step for 1 day. After that, the sun-dried apricots were stored in a cold room (0 to 2°C) with 15 to 17% water content. The physico-chemical analysis of dried apricots concerned the contents of water, protein, carbohydrate and lipid. Also, the energy value and dry matter content were determined. Likewise, the aflatoxin detection (B1, B2, G1 and G2) in dried apricots was done. These analyzes were carried out in collaboration with the company Eco2 Lab (Akouda-Sousse, Tunisia).

2.4. Statistical analyzes

Data for fresh and dried apricots were subjected to multivariate analysis using the General Linear Model (GLM) method and fixing the cultivar factor. The mean values of each parameter were compared between cultivars by Duncan's test ($P \leq 0.05$). SPSS 17.0 and Excel software were the tools used for this statistical analysis.

3. Results and discussion

The physico-chemical characterization of fresh apricots (fruit, flesh and stone) of the 10 apricot cultivars studied, showed great variability between cultivars for all studied parameters. The majority of cultivars exhibited a good to extremely good fruit attractiveness, a medium orange ground color and purple over color with strong intensity. The fruits of the cultivar "Bayoudhi" were distinguished by a yellowish ground color and a pink over color (Table 1).

Table 1: Physico-chemical characteristics of fruit of 10 apricot cultivars grown in the center-west of Tunisia

Cultivar	Attractiveness	Shape in ventral view	Ground color of skin	Over color			Aroma	Eating quality
				Relative area	Hue	Intensity		
Introduced cultivars								
Grilli	Good	Elliptic	Medium orange	Medium	Purple	Dark	Intermediate	Medium
85	Medium	Elliptic	Light orange	Small	Purple	Medium	Little	Medium
Precious	Extremely good	Elliptic	Medium orange	Absent	Nulle	Nulle	Intermediate	Medium
Golden	Extremely good	Ovate	Medium orange	Medium to large	Red	Dark	Rich	Good
Perlite	Extremely good	Circular	Medium orange	Very large	Red	Dark	Rich	Good
Local cultivars								
Ouardi	Extremely good	Ovate	Medium orange	Very small to small	Purple	Dark	Intermediate	Medium
Sayeb	Good	Ovate	Medium orange	Very small	Purple	Dark	Rich	Good
Kasserine 2	Extremely good	Elliptic	Dark orange	Medium to large	Red	Dark	Intermediate	Good
Amor Leuch	Good	Ovate	Light orange	Small	Purple	Dark	Intermediate	Medium
Bayoudhi	Good	Circular	Yellowish	Small to medium	Pink	Medium	Rich	Extremely good

The organoleptic evaluation allowed us to identify 2 introduced cultivars "Golden" and "Perlite" and 3 local cultivars "Sayeb", "Kasserine 2" and "Bayoudhi" which were distinguished by a rich aroma and good to extremely good taste quality (Table 1). Indeed, based on the chemical analysis of the fruit, the cultivar “Sayeb” produced the sweetest fruits (13.27 °Brix) followed by “Perlite” and “Kasserine 2” with similar contents (≥12.50 °Brix) (Figure 1). According to Lichou et *al.* [11], we could identify "Sayeb" as a very sweet cultivar (> 13 °Brix) and "Perlite" and "Kasserine 2" as sweet cultivars (12-13 °Brix). While, "Golden" and "Bayoudhi" were identified as moderately sweet cultivars (between 10.5 and 12 °Brix).Most cultivars were characterized by light orange to medium orange flesh color with an intermediate to coarse texture. While, the local cultivar “Bayoudhi” was distinguished by creamy fruits and a fine texture. “Bayoudhi” and “Amor Leuch” produced the firmest fruits (Table 2). However, according to Lichou et *al.* [11], the flesh firmness of all studied cultivars was classified as insufficient (<50 ID) (Table 2). For the percentage of flesh, the 2 cultivars "Golden" and "Kasserine 2" grouped together with the highest percentage of flesh (≤96%). Similarly, “Amor Leuch” had a percentage of close flesh (≥95%) (Table 2).

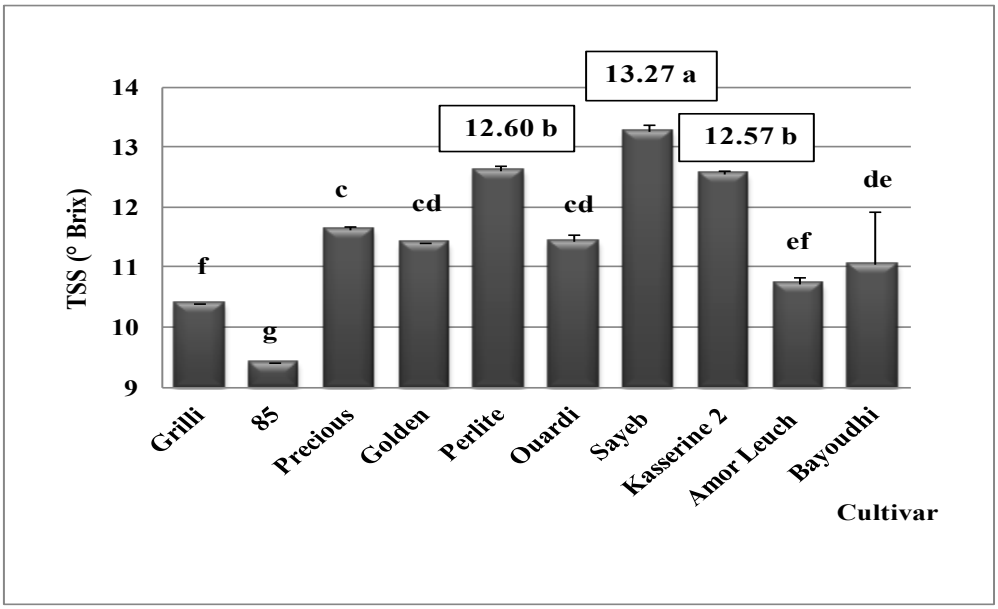

Figure 1: TSS (°Brix) of fruit of 10 apricot cultivars grown in the center-west of Tunisia

Table 2: Physico-technological characteristics of flesh of 10 apricot cultivars grown in the center-west of Tunisia

Cultivar	Color	Texture	Juicness	Firmness (DI)	Flesh (%)
Introduced cultivars					
Grilli	Medium orange	Intermediate	Intermediate	26.62 c	93.39 e
85	Light orange	Intermediate	Intermediate	27.33 c	89.49 h
Precious	Medium orange	Coarse	Juicy	21.07 de	93.99 d
Golden	Medium orange	Coarse	Juicy	24.12 cd	95.64 a
Perlite	Light orange	Intermediate	Intermediate	23.18 d	92.96 ef
Local cultivars					
Ouardi	Medium orange	Coarse	Juicy	19.07 e	92.65 f
Sayeb	Light orange	Intermediate to coarse	Juicy	19.40 e	91.61 g
Kasserine 2	Medium orange	Coarse	Juicy	19.52 e	95.62 a
Amor Leuch	Light orange	Intermediate	Intermediate	42.73 b	95.13 b
Bayoudhi	Cream	Fine	Intermediate	47.65 a	94.50 c

For these 3 cultivars mentioned, the percentage of the stonewas inversely proportional to the percentage of the flesh (Table 3). Most of the studied cultivars were distinguished by the weak adherence of the stone to the flesh. However, for the cultivar “Amor Leuch”, the stone was strongly adhered to the flesh (Table 3).

Regarding the juiciness of the flesh, the cultivars "Precious", "Golden", "Ouardi", "Sayeb" and "Kasserine 2" are distinguished by a juicy flesh (Table 2).

By referring to the standardization of the size of apricots [12], the fruits of the 2 introduced cultivars “Golden” and “Precious” were classified with an AA size (45 to 50 mm). While, the 2 local cultivars “Amor Leuch” and “Kasserine 2” were distinguished by the size A of their fruits (40 to 45 mm). The weight of fruit of the 2 previous introduced apricot cultivars was 62 g and 73 g, respectively. While, that of the 2 previous local cultivars was 42.6 g and 46 g, respectively (Figure 2). According to the international descriptors of apricot [9], “Golden” and “Precious” were identified as large and very large fruits, respectively. However, “Amor Leuch” and “Kasserine 2” were classified as small/medium and medium, respectively.

Table 3: Physical characteristics of stone of 10 apricot cultivars grown in the center-west of Tunisia

Cultivar	Adherence of stone to flesh	Stone (%)
Introduced cultivars		
Grilli	Absent or very weak	6.61 d
85	Weak	10.51 a
Precious	Weak	6.01 e
Golden	Weak	4.36 h
Perlite	Medium	7.04 cd
Local cultivars		
Ouardi	Medium	7.35 c
Sayeb	Weak	8.39 b
Kasserine 2	Weak	4.38 h
Amor Leuch	Strong	4.87 g
Bayoudhi	Medium	5.50 f

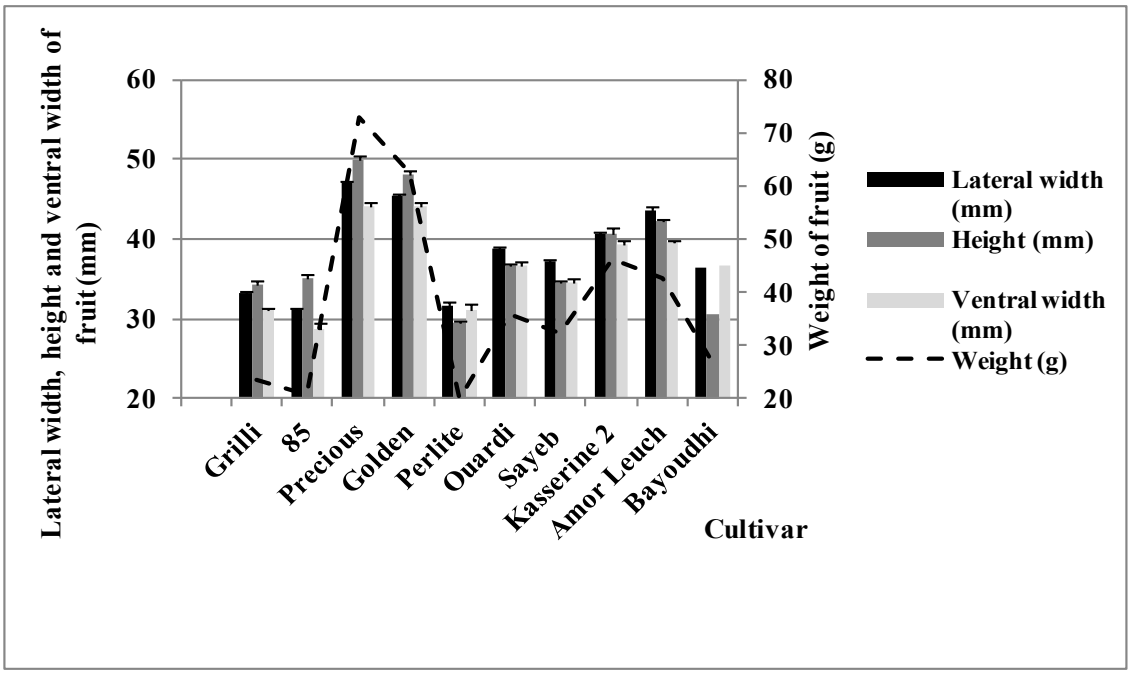

Figure 2: Morphometric characteristics of fruit of 10 apricot cultivars grown in the center-west of Tunisia

For dried apricots, the physico-chemical analysis of the sun-dried and sulfurized fruits showed that the cultivar "Kasserine 2" was characterized by the highest levels of carbohydrates and proteins (65.12% and 3.38%, respectively) and by a high energy value (277.32 Kcal/100 g) (Table 4). Likewise, this cultivar was individualized by the lowest moisture content (27.61%) and consequently the highest dry matter content (72.39%) (Figure 3). Dried apricots of the 2 local cultivars "Sayeb" and "Amor Leuch" had close levels of carbohydrates, proteins, water and dry matter (Table 4; Figure 3). The 3 introduced cultivars "Golden", "Perlite" and "Precious" were identified by their dry matter, carbohydrate and protein contents and also a high and similar energy value. “Golden” was distinguished by the highest values (Table 4; Figure 3). For these 3 cultivars, the values of the different physico-chemical characteristics of the dried apricots were close to those of the 3 local cultivars “Kasserine 2”, “Sayeb” and “Amor Leuch” (Table 4; Figure 3).

Table 4: Physico-chemical characteristics of dried apricots of 10 cultivars grown in the center-west of Tunisia

Cultivar	Energetic value (Kcal/100g)	Carbohydrates (%)	Protein (%)	Lipids (%)
Introduced cultivars				
Grilli	253.50	59.13	3.03	0.54
85	246.97	57.54	3.10	0.94
Precious	254.54	59.03	2.94	0.74
Golden	257.22	60.08	3.01	0.54
Perlite	255.89	59.81	3.06	0.49
Local cultivars				
Ouardi	250.89	58.54	3.17	0.45
Sayeb	252.45	58.95	3.15	0.45
Kasserine 2	277.32	65.12	3.38	0.40
Amor Leuch	250.43	58.47	3.08	0.47
Bayoudhi	240.49	55.99	3.12	0.45

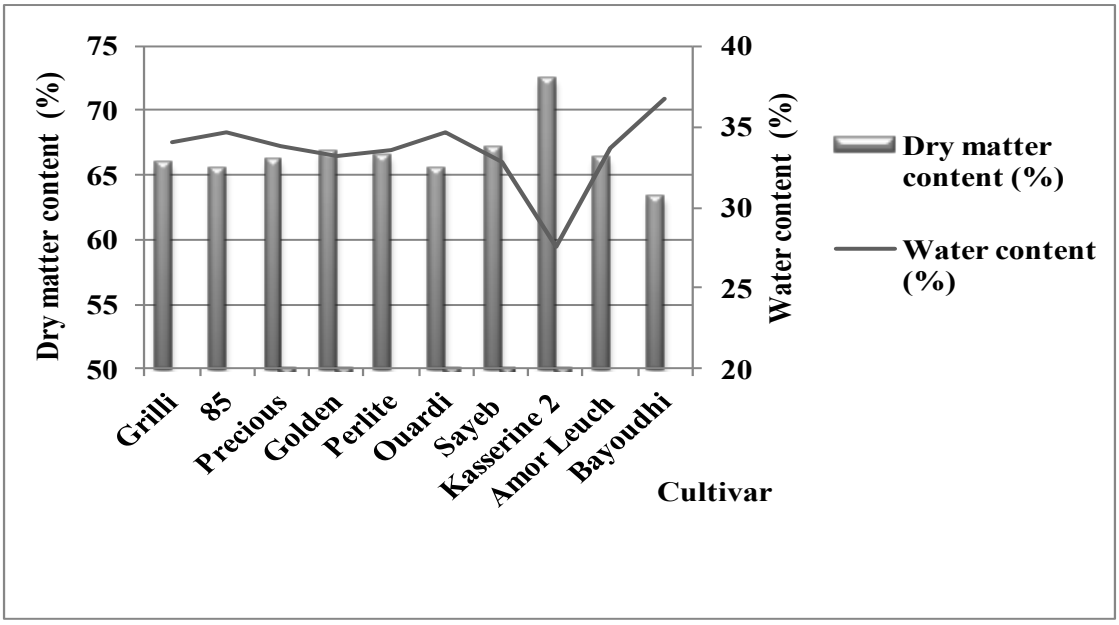

Figure 3: Dry matter and water content of dried apricots of 10 cultivars grown in the center-west of Tunisia

However, the cultivar “Bayoudhi” was individualized by the lowest dry matter and carbohydrate content (63.33% and 55.99%, respectively) and by the lowest energy value (240.49Kcal/100g) (Table 4; Figure 3). Table 4 showed that the lipid contents were very low and varied from 0.40% to 0.94%. At the same time, microbiological analysis of contaminants in dried apricots did not reveal the presence of aflatoxins (B1, B2, G1 and G2) for all cultivars studied. Results obtained are in good agreements with those obtained by others authors in various countries [13-15].

Conclusion

Fruit quality diversity was observed between the studied apricot cultivars (local and introduced) for all the physico-chemical and technological characteristics of the fresh and dried fruit. For some parameters, cultivars were grouped independently of their geographical origin. The results of this study allowed us to consider 3 local cultivars "Kasserine 2", "Sayeb" and "Amor Leuch" as promising for drying apricots. Their dried apricots were characterized by similar and high levels of carbohydrates, proteins and dry

matter. Likewise, their energy values were close and important. "Kasserine 2" was individualized by the highest values. In addition, these 3 local cultivars were distinguished by their good attractiveness of the fruit, good taste quality and juicy flesh. "Golden", "Perlite" and "Precious" as introduced cultivars can be used for drying. Their dried apricots were characterized by very high contents of carbohydrates and proteins. Their energy value and dry matter content were also very important.

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