



Evaluation of four medlar cultivars: agronomical, pomological and qualitative traits

V. Cristofori¹, C. Silvestri¹, A.L. Pica¹, G. Bertazza² and C. Bignami³

¹ Dipartimento di Scienze Agrarie e Forestali, Università degli Studi della Tuscia, Viterbo, Italy

² Istituto di Biometeorologia, Consiglio Nazionale delle Ricerche, Bologna, Italy

³ Dipartimento di Scienze della Vita, Università degli Studi di Modena e Reggio Emilia, Reggio Emilia, Italy

Summary

Medlar (*Mespilus germanica* L.) has been recently cultivated due to good potential for diversification of fruit production among the minor pome fruits. The species is subjected to high risk of erosion, since it is characterized by low genetic diversity. However, the genetic resources of cultivated and wild medlar are not well known. In the Italian nursery industries, only a limited number of cultivars are available, often characterized by absence of genetic fidelity. Therefore, a collection of the available medlar varieties has been established at the Experimental Orchard of Tuscia University, to carry out their pomological characterization and the evaluation of fruit quality and agronomical performance. **Objectives** – The study has been focused on vegetative and productive behavior of the cultivars and on pomological traits, organic acids, sugars and sensory profile of the fruits. **Material and methods** – The investigated cultivars were ‘Gigante’, ‘Precoce’, ‘Comune’ and ‘Goccia’. All the genotypes were grafted onto clonal quince rootstock BA29 (*Cydonia oblonga* L.). Three replications for each variety were randomly distributed in the field. The trees were trained in a free vase form. Soil was ordinarily managed for weed control, and drip irrigation supply was ensured during the summer period. **Results and conclusion** – The cultivar ‘Comune’, characterized by a high yield efficiency and good fruit quality, seems suitable for the establishment of specialized orchards for commercial purposes, while the cultivar ‘Gigante’, characterized by low productivity, could be interesting mainly for ornamental purposes.

Keywords

Mespilus germanica L., *in vivo* conservation, minor pome, fruit quality, sensory evaluation, yield efficiency

Introduction

Medlar (*Mespilus germanica* L.) belongs to the *Rosaceae* family, subfamily *Maloideae*. The genus *Mespilus* includes the species *germanica* (Phipps et al., 1991) and the recently discovered species *M. canescens*, both characterized by fruits (pomes) with wide-spreading persisting sepals, brown in *M. germanica* and glossy red in *M. canescens* (Shafi, 2014; Akbulut et al., 2016). The fruit becomes edible after being softened (or bletted) by frost, or after sufficient time of storage traditionally in straw at room temperature or currently in controlled conditions.

Significance of this study

What is already known on this subject?

- Medlar is a minor pome fruit whose genetic resources are subjected to high risk of erosion even though it represents a viable alternative for diversification in fruit production.
- The knowledge of this cultivated species is mainly focused on chemical traits and antioxidant characteristics during its fruit ripening, especially for a few number of local varieties as some Turkish biotypes.

What are the new findings?

- The phenological, vegetative and productive characteristics of some medlar cultivars suited for being cultivated in temperate climates.
- The pomological and qualitative fruit traits associated to the sensory evaluations.

What is the expected impact on horticulture?

- The high rusticity of medlar able to adapt to poor soils, its easy orchard management, the pleasant and delicate taste of the over-ripe fruit of some cultivars and its high nutritional value are valid requisites for promoting the cultivation of this ‘forgotten fruit’ in specialized orchards.

The medlar, originating in the southeastern part of the Balkan region, Caucasus, Crimea, and north of Iran and Turkmenistan (Baird and Thieret, 1989), is now widespread all over the world. The word “*germanica*” refers to the frequency with which Linnaeus found wild type accessions in Germany that was wrongly considered the origin area of this species, despite the discovery of fossils of the leaves in East Germany. The medlar was included among the proposals for minor species diversification of fruit production (Bignami, 2000). As a result, these fruits are more widely available in niche markets than in past years. Nevertheless, in the Mediterranean countries, in Eastern Europe and in Central Asia this minor pome fruit is not cultivated in specialized orchards or in industrial plantations (Asadov, 1987; Khadivi et al., 2019). In Italy, the marketable fruits come almost exclusively from plants scattered in few orchards and gardens; for this reason, the volume of the products currently commercialized is not easily estimable due to the lack of official statistics.

The growth in fruit demand concerns not only Italy but also other European countries such as Austria (Kirisits, 1999), Germany and Greece (Brust, 1997) and it is due to the importance of this fruit as a source of phenolic compounds

and natural antioxidants (Akbulut et al., 2016; Ayaz et al., 2008; Rop et al., 2011; Gruz et al., 2011; Gulcin et al., 2011; Nabavi et al., 2011; Selcuk and Erkan, 2015). In addition to fresh consumption, medlar fruits are also used to produce wine and jelly (Bostan and Islam, 2007; Aygun and Tasci, 2013), jams and vinegar.

Medlar is considered a species with narrow genetic base and therefore subject to high risks of genetic erosion. The cultivars available are very few and in most cases these genotypes have an ancient origin (Tamaro, 1940; Peyre, 1945; Baird and Thieret, 1989; Reich, 1994). This limited evolution of medlar diversity can be ascribed to the lack of economic interest for this fruit species in the last centuries, despite the long tradition of use. The genetic variability found in spontaneous biotypes or semi-domesticated is also little known. The greatest number of medlar ecotypes has been listed by Evreinoff (1953), which refers to 23 different accessions, also comprising wild forms or semi-wild, ornamental and of different origin.

The availability of varieties in Italian nursery industries is rather limited. The cultivar 'Comune', 'D'Olanda' (Gigante d'Olanda) and 'Reale' are the most widely marketed. However, the varietal name 'Comune' is quite generic and seems to refer to a cultivar-population that differs for pomological traits. Its clones are also found as local selections ('Castelraniero'), for which the fingerprinting needs to be verified. In other European countries, the situation is not very different; in Greece are cultivated mostly large-fruited medlar, referring to the subspecies "*macrocarpa*". In Austria and England, the cultivar 'Nottingham' is the most known and widespread.

An accurate knowledge of the available variability for this minor fruit species can be a valuable tool for the enhancement of its use as an additional opportunity for the differentiation of fruit supply (Barbieri et al., 2011) and can help to ascertain the varietal identity shedding light on putative synonyms. Therefore, four accessions currently available in Italian nurseries have been collected at Tuscia University, following a preliminary pomological characterization of a wider number of cultivated and wild accessions *in situ* and *on farm* within the framework of the EC Project RESGEN29 "Conser-

vation, evaluation, exploitation and collection of minor fruit tree species" (Bignami, 1998, 1999; Mendoza de Gyves et al., 2008). The characterization and evaluation of fruit traits and quality and agronomical performance have been carried out with the aim of gathering useful information for the varietal classification and for a better commercial exploitation.

Materials and methods

Plant material

The four medlar cultivars 'Comune', 'Gigante', 'Precoce' and 'Goccia' under investigation were planted in 1997 in the experimental farm of Tuscia University (latitude 42°25'N, longitude 12°08'E, altitude 300 m). Three plants per accession were grafted on clonal quince rootstock BA29 and were trained in a free shape form spaced 4.0 × 2.5 m. The soil was managed with a natural green cover crop according to the rules of the Fruits Integrated Production System (Regione Lazio, 2000) and received the applications of the following quantities of general fertilizers: 90 kg ha⁻¹ N, 60 kg ha⁻¹ P₂O₅ and 60 kg ha⁻¹ K₂O. Drip irrigation supply was ensured during the summer period. The experimental field is characterized by a clay loam soil, pH 7.6, with 1.9% organic matter content.

Vegetative traits and production

Vegetative and productive behaviour of each tree was recorded over the period 2014–2016. The vegetative growth was determined measuring the trunk-cross sectional area (TCSA) 30 cm above the ground at the end of each vegetative season (late October). At the end of the first year the annual development of shoots was also measured selecting two shoots per plant located in the external and equatorial position of the crown and with exposure to North and South, respectively.

The dynamics of the phenological phases were followed in the field by periodically detecting the main stages as described by Bellini et al. (2007). The considered stages were swelling of the buds, open bud, appearance of the green flower bud, open flower-full bloom, fruit set, and fruit at harvest maturation.



FIGURE 1. Ripe fruits of the four medlar cultivars in comparison with a wild type fruit (a = 'Precoce'; b = 'Gigante'; c = 'Goccia'; d = 'Comune'; e = wild type).

Yield was determined by weighing the fruits of every tree. Harvest was done in the second half of October when the fruits were fully developed and physiologically ripe, with the only exception of 'Precoce' that showed some fruits starting to over-ripe on the tree.

Yield efficiency was calculated with the following formula: yield efficiency (YE) = yield \times TCSA⁻¹ for each accession and year.

Pomological traits

At harvest a representative sample of fruits (60 per tree) were collected and stored into a paper bag at +4°C, for the pomological characterization (Figure 1). The fruit weight, height, equatorial diameter and the seeds/fruit weight ratio were measured. The shape index was calculated as height/equatorial diameter ratio and the obtained values compared with the descriptor "fruit shape in longitudinal section" (Bignami, 1998, 1999).

Sugar and acid characteristics in bletted fruits

During the first year of investigation, after harvest a sample of fruits was stored at room temperature for promoting the bletting and, on average after two weeks, the bletted flesh was lyophilized for analyses. Qualitative and quantitative determination of soluble sugars and organic acids was carried out by gas-liquid chromatography (GLC) according to Bartolozzi et al. (1997). A 5-g flour of lyophilized flesh was extracted in 100 mL of a solution of imidazole (0.05 M, pH 7.2) and ethanol (1:1 v/v), to which were added β -phenylglucopyranoside (2.5 mg) as an internal standard and the antioxidant butylated hydroxyaniline (BHA). A 2-mL aliquot of the extracts was evaporated to dryness, treated with 500 μ L pyridine, 200 μ L hexamethylsilazane and 100 μ L trimethylchlorosilane and heated at 50°C for 1 h. The trimethylsilyl derivatives were injected into a Chrompack CP 9000 GC equipped with a splitter injector, a flame ionization detector and a CP-Sil-5CB capillary column (25 m, 0.25 mm i.d., 0.12 mm film thickness) (Chrompack, Middelburg, The Netherlands). The temperature of both the injector and detector was 350°C. The column temperature was held at 120°C for 1 min, then increased at 10°C min⁻¹ to 180°C, at 15°C min⁻¹ to 270°C, and at 20°C min⁻¹ to 350°C, and finally held at 350°C for 6 min. The retention times of the standards of the main sugars (fructose, glucose, sucrose and sorbitol) and organic acids (malic, citric, quinic and succinic) expected to be found in *Rosaceae* pomes were used for qualitative determination.

Sensory evaluation

At the end of November 2014, anonymous samples of bletted flesh were submitted to eleven panellists previously trained for a better knowledge of the meaning of the chosen attributes. The evaluation was carried out in a room equipped with individual sites and with white incandescent light. The samples were submitted in two replicates for each cultivar, randomizing the samples order. During the sensory tests the panellists were invited to drink a sip of water and eat some unsalted crackers between samples, in order to avoid tiring effects. The following characteristics were considered: fermented, alcoholic, sweetness, acidity, astringency, flavour, firmness, fibrousness, grittiness. The level of taste and flavour appreciation was also requested. To avoid influences on the evaluation of flesh sensory attributes, the external appearance of the fruits at bletted stage was evaluated by the panellists only after the tasting session. Sensory score sheets with an 11-cm unstructured line scale were used for

descriptive terms. The judges were requested to indicate the intensity of each attribute by placing a vertical line on the unstructured scale line. The scores were then quantified according to distance from the origin and the vertical line.

Statistical analysis

Statistical analyses were carried out using InfoStat Professional v.1.1 program. All the parameters were subjected to analysis of variance (ANOVA). Differences were accepted as statistically significant according to Fisher's test ($p \leq 0.05$). In order to analyze the responses of cultivars among the year and their possible interaction, the data of vigour, production and pomological traits were also analysed by two-way ANOVA.

The annual shoot development was expressed as mean \pm standard deviation, whereas the average values of sensory analysis were represented as radar-type graph.

Results and discussion

Vegetative traits and production

The medlar accessions showed a high variability for the vegetative and productive traits. All varieties showed a significant diversity in plant vigour, expressed as TCSA (Table 1). The final values (2016) ranged from 187.46 cm² for the less vigorous 'Gigante' and 232.25 cm² for the most vigorous 'Precoce'. The medium vigorous 'Comune' and 'Goccia' showed a linear increase of TCSA during the years of investigation, and the mean value was around 185.0 cm² for both cultivars. Conversely, the accessions 'Gigante' and 'Precoce' showed a high increase of the TCSA in the last year of investigation in comparison to the previous two years.

Figure 2 shows the average values of the axial length of the shoots detected at the end of summer 2014, distinguished by orientation in the crown to the north and south.

All cultivars, with the exception of 'Precoce', showed a higher development of the sprouts exposed to the South, favored by better lighting compared to the North-oriented shoots. The greater development of the shoots exposed to the North of the 'Precoce' is probably due to a lower presence of fruit in this side of the plants, recorded during the year, which may have therefore favored the translocation of carbohydrates in the vegetative structures of the plants.

The development of the shoots also showed a greater vigor of the 'Precoce' cultivar that had an average length of 26.7 cm for the shoots exposed to the North and 22.2 cm for the shoots exposed to the South, while the cultivars 'Comune' and 'Gigante' highlighted the shoots development more contained and lower than 15.0 cm when exposed to the North.

It is also interesting to point out that the most active period in the axial lengthening of the shoots lasted until July, while the vegetative growth was halted in the following months, coinciding with the enlargement of the fruits (data not shown).

The main phenological stages recorded on the four cultivars are summarized in Table 2. Bud break was concentrated in the middle part of March in all cultivars, while the beginning of vegetative growth occurred in the last ten days of March for 'Precoce' and 'Goccia', and at the beginning of April for 'Comune' and 'Gigante'. The appearance of the flower buds was observed in mid-April, while the full bloom coincided with the second ten days of May and persisted for about a week. In the last ten days of May there was the first phase of growth of the fruits, which reached the harvest maturation between the end of October, for 'Precoce' and 'Gigante', and the beginning of November, for 'Comune' and 'Goccia'.

TABLE 1. Yield, trunk-cross sectional area (TCSA) and yield efficiency (YE) of four cultivars of medlar ('Comune', 'Gigante', 'Goccia', and 'Precoce') over three years of investigation as means of three replicates \pm standard deviation. Values followed by different letters are significantly different according to the Fisher's test ($p \leq 0.05$). (Significance: * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$).

Cultivar	Year	Yield (kg plant ⁻¹)	TCSA (cm ²)	YE (kg cm ⁻²)
'Comune'	2014	50.38 \pm 0.14	183.76 \pm 3.46	0.26 \pm 0.002
'Gigante'		11.41 \pm 2.17	150.68 \pm 14.02	0.07 \pm 0.011
'Goccia'		29.92 \pm 7.43	186.16 \pm 5.79	0.15 \pm 0.007
'Precoce'		35.09 \pm 1.64	203.22 \pm 3.78	0.17 \pm 0.008
'Comune'	2015	35.86 \pm 1.97	186.19 \pm 14.01	0.19 \pm 0.009
'Gigante'		6.45 \pm 1.20	154.46 \pm 13.78	0.04 \pm 0.003
'Goccia'		29.25 \pm 4.86	187.46 \pm 6.08	0.15 \pm 0.037
'Precoce'		37.76 \pm 5.90	211.54 \pm 3.08	0.19 \pm 0.047
'Comune'	2016	24.49 \pm 2.42	189.34 \pm 11.58	0.12 \pm 0.010
'Gigante'		7.31 \pm 0.32	187.46 \pm 11.94	0.04 \pm 0.001
'Goccia'		11.42 \pm 3.17	191.24 \pm 5.53	0.05 \pm 0.006
'Precoce'		14.07 \pm 3.03	232.25 \pm 7.70	0.06 \pm 0.001
Average cvs.	2014	31.70 ^a \pm 6.37	180.95 \pm 21.01	0.16 ^a \pm 0.078
	2015	27.33 ^a \pm 4.73	184.91 \pm 22.96	0.14 ^a \pm 0.074
	2016	14.32 ^b \pm 8.84	200.07 \pm 21.10	0.07 ^b \pm 0.014
'Comune'	Average years	36.91 ^a \pm 7.34	186.43 ^{bc} \pm 13.06	0.19 ^a \pm 0.025
'Gigante'		8.39 ^b \pm 2.77	164.20 ^c \pm 19.81	0.05 ^b \pm 0.019
'Goccia'		23.53 ^{ab} \pm 9.17	188.23 ^b \pm 11.72	0.12 ^{ab} \pm 0.020
'Precoce'		28.97 ^a \pm 11.74	215.67 ^a \pm 19.08	0.14 ^{ab} \pm 0.016
Source of variation				
Cultivar		***	***	***
Year		*	n.s.	***
Cultivar * Year		n.s.	n.s.	n.s.

The accession 'Comune', with an average yield of 36.91 kg tree⁻¹ was the most productive variety in the collection in the three years of the trial. A high production was also observed for 'Precoce' and 'Goccia' (28.97 and 23.53 kg tree⁻¹, respectively), while 'Gigante' was the lowest yielding cultivar in the years of investigation, with an average value of 8.39 kg tree⁻¹.

The lowest yield was recorded in 2016 for all cultivars due to the moderate tendency to the biennial bearing of the species, similarly to other pome fruits. Conversely, in the first year of investigation the cultivars showed the highest yield as a consequence of a vigorous pruning applied to the trees

during the year 2013, which stimulated the flower induction in the following year.

Moreover, the yields recorded in our trial were higher than those observed in other investigations (Sulusoglu Durul and Unver, 2016), probably due to the influence of genotype, environment and especially for the different orchard management techniques applied.

The yield efficiency (YE) was significantly affected by the variety and by the year (Table 1). The highest value of mean yield efficiency (YE) was calculated for 'Comune' (0.19 kg cm⁻²), while 'Gigante' showed the lowest mean YE with val-

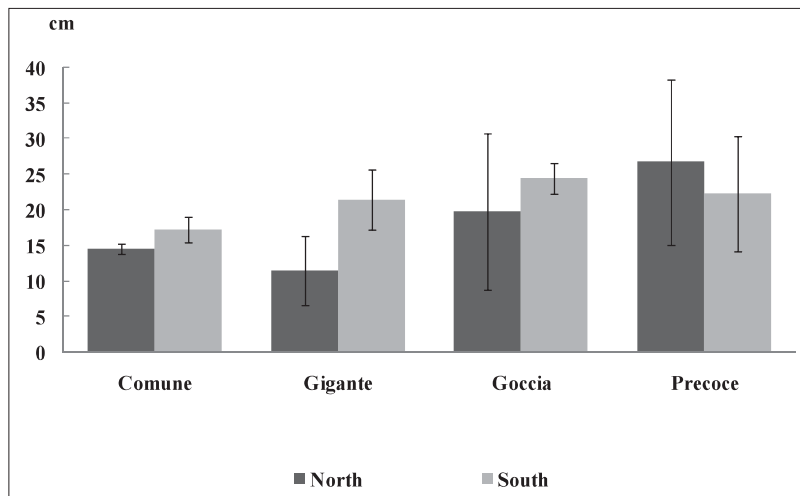


FIGURE 2. Axial shoots length oriented in the North and South part of the crown at the end of the growing season 2014 (mean \pm standard deviation).