

MINI REVIEW

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# The fig (*Ficus carica* L.): varietal evolution from Asia to Puglia region, southeastern Italy

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## Abstract

The fig represents one of the oldest and widespread species in the Mediterranean basin, and thanks to man-made selections, it is possible to survey numerous varieties currently used for both main crop and brebas production. The fig is often associated with the birth of horticulture in Mediterranean and Near Asia areas. Figs were probably carried to southern Italy by Phoenicians and successively by Greeks and played an important role in Roman society. Puglia was in the past the most important region in southern Italy to produce figs and especially brebas (first crop), thanks to the excellent qualitative aspects of some varieties such as 'Petrelli' (syn. "Fiorone di S. Giovanni," "Fiorone di S. Antonio") and 'Domenico Tauro' that are mainly cultivated in the provinces of Bari and Brindisi. Main crop production, on the other hand, has always been based on the 'Dottato' variety, which was mainly used for drying and is partly consumed fresh, but also processed into jams and marmalades. There are numerous 'minor' varieties, which allow Puglia to be among the regions in the world with the greatest fig biodiversity, a kind of living repository grown during the centuries and in the last years rediscovered. However, the consumption and trade are exclusively at the local level, due to limited resistance to handling and shipping of such fruit; only a limited amount is destined to export. The main fig varieties cultivated in Puglia allow a wide ripening calendar starting from the first 10 days of June for brebas (often at the end of May) and ending in late September–October with late ripening varieties. The purpose of this mini review is to highlight the high degree of biodiversity that exists in Puglia region since many centuries, and the importance that this ancient crop could have in modern fruit growing, as it was once a key player in market scenarios in many Mediterranean and Near Asia countries. The fig biodiversity could be used either for fresh and processed consumption or for breeding programs for new varieties with desired traits and qualities.

**Keywords** Biodiversity breba fruit, *Ficus carica* L., Main crop

## Introduction

The common fig (*Ficus carica* L.) belongs to the Moraceae, with over 1400 species classified into about 40 genera (Watson and Dallwitz 2004). The genus *Ficus*, comprised of about 700 species, is found mainly in the tropics, and currently classified into six subgenera which are characterized by a particular reproductive system

(Berg 2003), by the presence of latex and the inflorescence enclosed within a syconium (false fruit) that bears what is the true fruit, a druplet (Armstrong 2012). The fig is the third classical fruit crop associated with the beginning of horticulture in the Mediterranean basin and south-west Asia (Zohary and Spiegel-Roy 1975), and is cultivated in most Mediterranean-type climate (Flaishman et al. 2008). It seems that it was in the Mediterranean basin that its domestication took place, starting with groups of wild plants belonging to the genus *Ficus* (Zohary and Hopf 2000). According to Kislev et al. (2006), fig has been recently proposed to be the first domesticated fruit species, based on archaeobotanical evidence that show the use of parthenocarpic fruit during

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the 12th millennium B.C. According to Sinha (2003), the fig is native to the southern Arabian Peninsula, although other authors report the coasts of the Caspian and westernmost ranges of Turkey as its place of origin (Jona and Gibaudo 1991). The species is indigenous to Persia, Near Asia, and Syria and currently grows wild in most of the Mediterranean countries (Condit 1947; Ramirez 1974; Storey 1975; Aksoy 1998; Weiblen 2000; Zohary and Hopf 2000; Datwyler and Weiblen 2004). In Greece it arrived via the same island route of the eastern and central Cyclades, as other fruits and plant of oriental origin, including the pomegranate and palm tree (Mata Parreño et al. 2010). Only more recently (first half of the 1500s) the crop has been introduced to Britain, China, Japan, Australia, and South Africa, while its spread has been slower in Southeast Asian countries because of the wetter climate (Aksoy 1998).

#### Classification and floral biology of the fig tree

*Ficus carica* has a peculiar reproductive system, being a dioecious species with three functionally different flower forms and species-specific pollination entrusted to a small hymenopteran called *Blastophaga psenes* (Condit 1932, 1947; Galil 1977; Janzen 1979; Valdeyron and Lloyd 1979; Kjellberg et al. 1987; Beck and Lord 1988). Other species of the genus *Ficus* (*F. religiosa*, *F. sycomorus*), however, are monoecious. The two distinct sexual forms are known, respectively, as the domestic fig (or female plant) that produces edible fruit and the caprifig (or male plant) used for caprification in varieties where it is required (Stover et al. 2007). Caprification is an ancient pollination technique required for non-parthenocarpic varieties and involves placing profichi containing pollen on the female plant, which through a vector (*Blastophaga psenes*) will reach the main crop inflorescence allowing pollination and fruit set (Marcotuli et al. 2020; Sarkhosh et al. 2022). This is a common practice in major fig-growing regions and has important repercussions on the amount and quality of harvested fruit (Mars 1995). The fruits of the male plants (caprifigs, from the Italian word 'capra', the goat, since goats used to eat the fruits of the male plants) are generally nonedible and can be very different in shape, size and coloration. According to Pontedera (1720), they belonged to different species, while Gasparrini (1845a, b) asserted that they were even different genera, namely *Ficus* and *Caprificus*. Bauhin (1623), defines them as *Ficus communis* and *Ficus humilis*, respectively; whereas Celi (1907) distinguished *Ficus carica sativa* and *Ficus carica sylvatica* with non-edible fruit. Depending on variety, the domestic fig may produce in the same year, one, two or even three crops, allowing varieties to be classified as uniferous, biferous and triferous. The first fruiting develops from fruiting

buds, located at the axil of the leaf in the distal part, formed in the previous season, from which the brebas originate, which ripen early in summer (May–June–July). The second crop, on the other hand, develops from buds always placed in the axil of the leaf but developed in the current year, during shoot growth, which generally ends when temperatures drop (in the late summer or autumn period) and daylight shortens. Some varieties (Fico Pasqua, Fico tre volte, and Fico Natalino), bear, in addition to the two described crops, another production, from the current year's buds, which ripens in late autumn or winter, typical of areas where there is no excessive cold or frost. These latter varieties generally bear fair amounts of syconia, and the late crop is called the winter or Christmas crop, already known by the ancient Romans. Similarly, caprifigs can also bear multiple (up to three) crops throughout the year; most varieties are triferous producing mammoni, profichi and mamme, respectively, but there are many cases in which it behaves as a uniferous and biferous tree (Grassi 1991). Although there are differences between the two sexual forms, there are some similarities between the crops; in particular, the first production (brebas) is like that of the profichi of the male plant, while the second production (main crop) can be considered similar to the mammoni of the caprifig (Condit 1932; Morales and Gil 2014; Marcotuli et al. 2023a, 2023b).

#### Importance, evolution and fig production in the world and in Italy

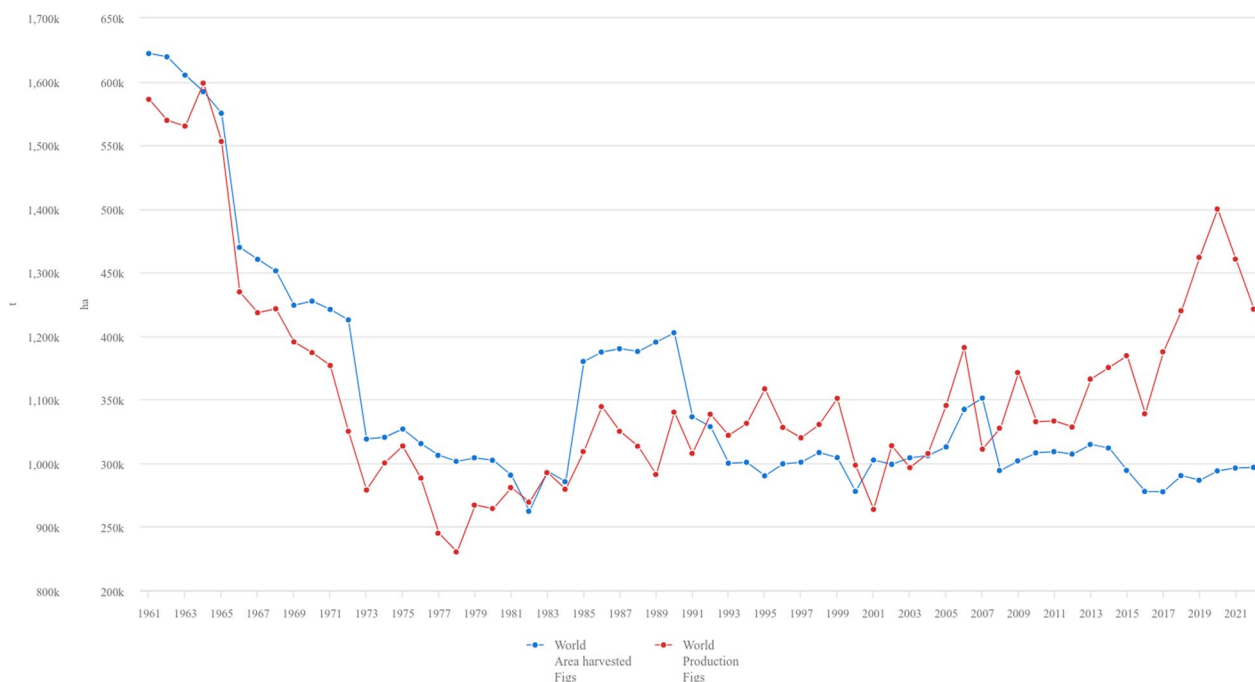
The fig is an important food component of the Mediterranean diet and appreciated for its organoleptic characteristics, color, sweetness, aroma, and for its richness in minerals (potassium, iron, calcium), vitamins (riboflavin and thiamin), as well as 17 amino acids, fiber, polyphenols and possesses a high antioxidant activity able to fight some degenerative diseases (Sarkhosh et al. 2022). It also has no cholesterol, fat, or sodium (Vinson et al. 2005; Lianju et al. 2003; Crisosto et al. 2010; Slavin 2006; Trad et al. 2014; Vinson 1999; Ouchemoukh et al. 2012; Solomon et al. 2006; Viuda-Martos et al. 2015; Veberic et al. 2008; Viuda-Martos et al. 2015). Since ancient times, the possibility of drying the fruits allowed to extend their consumption throughout the year, in addition to the seasonal consumption of the fresh product (Trichopoulou et al. 2006; Solomon et al. 2006). In Italy the species is practically present throughout the country as a minor cultivation, while we find it in specialized cultivation only in some southern regions such as Campania (area of Cilento), Puglia (Bari province and Salento area), and Calabria (Cosenza area). In Italy the surface of areas devoted to figs has shown a decreasing trend since the 1940s, a time when the Puglia region produced large

amounts of figs. In the four-year period 1939/42, more than 32,000 hectares were recorded, followed by Calabria (14,800 hectares), Sicily (3400 hectares) and Campania (2250 hectares), with the national area slightly exceeding 50,000 hectares. Only few years later, (1948/57), although Puglia still holds the largest areas, it reduced to about 22,000 hectares, as does the other producing regions, marking a national value of 40,000 hectares (Ferrara 1986). The decrease in area has continued to the present day but with a slight increase lately reaching 2071 hectares in 2023 for the whole country and 500 ha are located in Puglia (ISTAT 2024). Currently, national harvested production accounts for 13,000 tons (ISTAT 2024), with Puglia contributing with around 3200 tons (ISTAT 2024). World areas have also drastically reduced from about 622,000 hectares in 1960 to about 300,000 in 2022 (FAOSTAT 2024) (Fig. 1). Along with this area reduction, production of figs has reduced from about 1,900,000 tons in 1970 to 1,242,449 tons in 2022 (FAOSTAT 2024), but improved cultivation techniques and appropriate varietal choices have allowed yields per hectare to increase from 2.7 tons in 1970 to 4.2 tons in 2022 (FAOSTAT 2024). Among the Mediterranean producing countries, Turkey, Algeria, Egypt, Morocco, Greece, Italy, and Spain stand out, from which about 70% of fig production is obtained, with Turkey (350,000 tons) as the leading country (Melgarejo 2017; Sadler and Ateyyeh 2006; Sarkhosh et al. 2022; ISTAT 2024). North Africa is an important area for

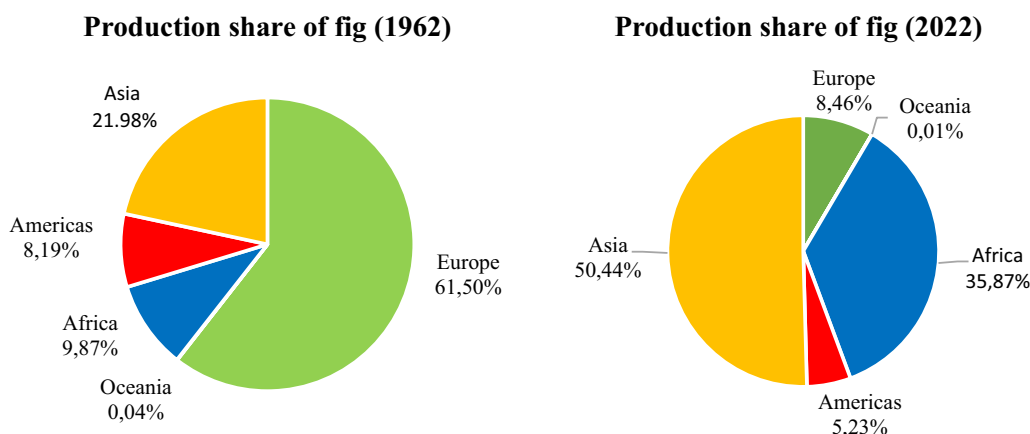
fig cultivation and produced in 2022 over 50 percent of the entire world production with important countries such as Egypt (187,000 tons), Morocco (110,000 tons) and Algeria (112,000 tons) (Maghsoudlou et al. 2017; Veberic et al. 2008; Viuda-Martos et al. 2015; FAOSTAT 2024). USA, Afghanistan, Tunisia, Albania, Greece, China, India and Japan are also important production countries. In Europe, Spain is the major producer of figs, with around 43,500 tons in 2022, representing 41.4% of European production (105,159 tons) and 3.5% of the world's production in 2022 (FAOSTAT 2024). The most important countries where fresh figs are imported are in Europe (Germany, France, Austria, Switzerland, and the United Kingdom) followed by the U.S., Russia, and the United Arab Emirates with a world value market of \$255 million (FAOSTAT 2024). However, dried fig is the most traded product type with 144,000 tons exported, a world value market of \$410 million (FAOSTAT 2024), and more than half of the world production comes from Turkey (Yilmaz et al. 2017; Caliskan and Polat 2008) (Fig. 2).

**Varieties and fig landraces**

The number of fig varieties is enormously large, especially considering the many cases of homonymy or synonymy (Aljane and Ferchichi 2009; Aljane 2011; Aljane et al 2012; Aljane and Nahdi 2014) and according to some authors it is around 600 reported varieties with a high genetic diversity (Melgarejo et al. 2003;



**Fig. 1** Changes in area and production of figs in the world over the past half-century (adapted from FAOSTAT 2024)

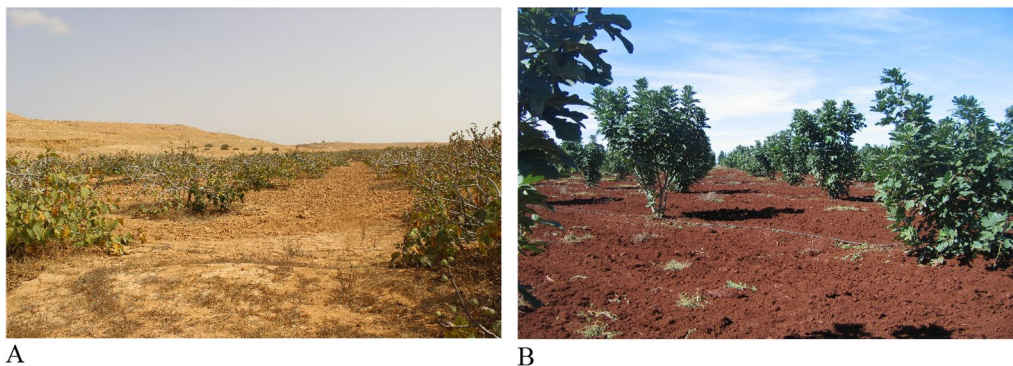


**Fig. 2** Changes in the producing areas over the last 60 years (average 1962–2022) (from FAOSTAT 2024)

Salhi-Hannachi et al. 2006; Almajali et al. 2012; Caliskan and Polat 2008; Pereira et al. 2020). Condit (1955) described about 720 varieties, while for other authors it would be as many as 800, cultivated mainly in moderate, hot, and dry climate environments, such as different regions of the Middle East but also the Mediterranean basin in countries like Egypt, Morocco, Turkey, etc. (Fig. 3) (Harzallah et al. 2016; Meziant et al. 2015; Crisosto et al. 2011; Ouchemoukh et al. 2012; Solomon et al. 2006). The most widespread and important ones are “Mission”, “Brown Turkey”, “Kadota”, “Bursa siyahi”, “Sarilop”, and “Sarizeybek” (Crisosto et al. 2010; Yemis et al. 2012) Many of the varieties currently cultivated come from selection of plants that originated from seed (Gasparrini 1845a, b; Chessa et al. 2014; Sarkhosh et al. 2022), as well as introductions that occurred over the centuries by sailors and rulers as the plant is easily propagated by cuttings. The fig, from its native sites has spread over the millennia first throughout the Mediterranean, and then to the rest of the world. In many of these areas, in fact, there are wild forms or landraces,

because a consequence of a process of acclimatization and environmental adaptation, led man to a subsequent selection, depending on productivity but also on the destination of the product of many varieties.

This has occurred in several countries such as Egypt and Libya (Abdelsalam et al. 2009), Turkey (Gozlekci 2010; Caliskan and Polat 2012; Caliskan et al. 2018), Italy (Ciarmiello et al. 2015), Croatia (Marcotuli et al. 2019), Algeria (Boudchicha et al. 2018), Tunisia (Saddoud et al. 2007; Gaaliche et al. 2012; Ben Abdelkrim et al. 2015; Haffar et al. 2017), Spain (Perez-Jimenez et al. 2012) and others. The large number of varieties also depends on the ease with which chimeras occur within the species, as the case with the “Fico Rigato” originated from the variety Lardaro (Gasparrini 1845a, b), also observed by Grassi (1990), which is genetically different from the French cultivar “Panachè” (Lumare 2007). However, many of the varieties mentioned in the literature, in the various historical periods, are partly disappeared or referred to by different names (Ferrara et al. 1991). In the last years, national repositories present in the Mediterranean



**Fig. 3** A rainfed fig orchard in a wadi in Egypt (A) and an irrigated fig orchard in Morocco (B)



basin collected hundreds of fig varieties in Europe (430) between Italy, Spain, and France, over 250 in Turkey and 200 in Morocco (Chessa et al. 2014). In Italy, the first descriptive studies of the different fig varieties cultivated in central-northern area of the country were initiated by Galesio (1817), and reported in his great work “Pomona Italiana”, which represented the basis for all subsequent studies (Targiotti-Tozzetti 1853; Roda 1881; Baldini 1982, 1994, 1995; Ferraro 1996).

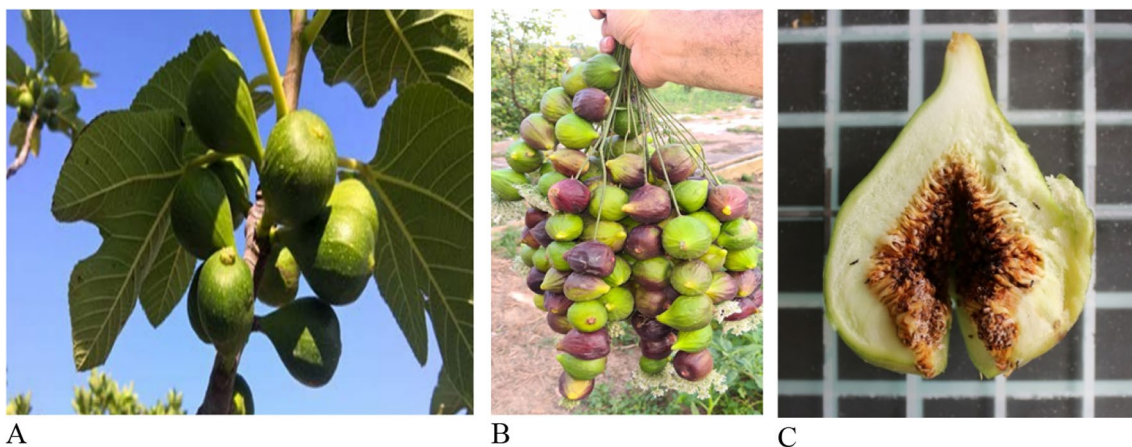
### Fig classification

*Ficus carica* has played a very important role in human nutrition over the millennia (Sarkhosh et al. 2022). Most wild figs, or very close to the wild form (caprifig), which are quite common in the Middle East and the Mediterranean, are distinguished essentially by a mutation affecting the flowers of the inflorescences, which, due to the suppression of the androecium, are all functionally female making the syconium succulent and therefore edible. A first, simple classification of varieties is based on the characteristics of the fruit such as the color of the skin, which can vary from green/yellow to blue or dark purple (Solomon et al. 2006), the time of ripening (early, late, or very late), or even the number of crops, 1/2/3 per year (fall, spring, and summer or summer only) (Ouchemoukh et al. 2012; Vallejo et al. 2012), and finally on the destination of the product (consumed fresh, with and without skin, dehydrated, as jam or juice, etc.) (Caliskan and Polat 2008, Aljane and Ferchichi 2009; Harzallah et al. 2016; Hoxha and Kongoli 2016; Solomon et al. 2006; Ferrara et al. 2023). Another important classification concerns production aspects and pollination, according to which figs are classified into 4 types. The “Common type” (Ct) has syconia with long-styled flowers, able to develop and reach maturity without pollination (caprifigation); they

can bear two crops per year (breba and main crop) and pollination improves some characteristics of the fruit (increase in size, change in flesh color and texture and taste) (Condit 1947; Ferrara et al. 2016; Marcotuli et al. 2020, 2023a). The most important and widespread varieties include “Adriatic”, “Brown Turkey”, and “Mission”. The other two types of domestic fig, however, require pollination for the fruit to develop and botanically are referred to as “cauducous”. They belong to the “Smyrna type” (St) with varieties as “Sarilop”, “Zidi”, and “Marabout” and the “San Pedro” type (SPt), with varieties as “Dauphine”, “King”, and “San Pedro”. In the “San Pedro type”, the plants bear two crops, one early (brebas) in which caprifigation is not necessary, and the second (main crop), which if not pollinated will drop early. This represents the only example in which two crops defined as “persistent” and “non-persistent” develop on the same season. In the “San Pedro type”, the production of brebas is much more abundant and important than that produced by the “common” type. A fourth and final type of fig is exploited as a source of pollen needed for caprifigation in commercial plants, and it is represented by the caprifig (male fig or goat fig) (Fig. 4A–C). Its function does not end with the production and maturation of pollen, but continues throughout the year thanks to its various fructifications, which, by the presence of short styled female flowers, allow the *Blastophaga psenes* to complete its biological cycle. The male flowers, present in a confined area (ostiole) produce abundant amounts of pollen (Galil and Eisikowitch 1968; Galil and Neeman 1977; Kjellberg et al. 1987).

### Fig varieties and cultivation in Puglia region

The fig varieties grown in Southern Italy were described in the early 1900s by Guglielmi (1908) and Vallese



**Fig. 4** The caprifig, with the profichi fruits (A), crowns of profichi used for the pollination (B) and a section of a profico fruit with some adults (black spots) of *Blastophaga psenes* clearly visible (C)

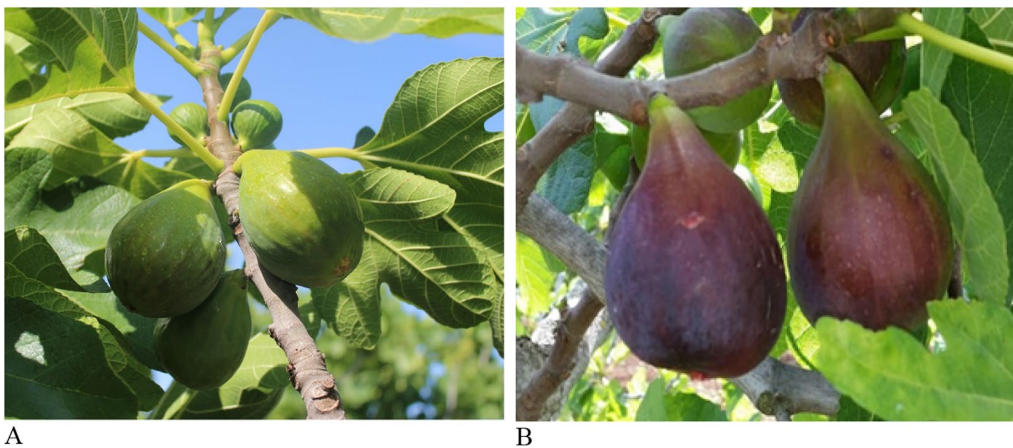
(1909), and later other authors deepened and studied the main varieties noticed in Salento area (De Rosa 1911; Donno 1948, 1951, 1959, 1972; Minonne 2001, 2002, 2007, 2008, 2009, 2011) and in the province of Bari (Ferrara 1990, 1991, 1992, 1998, 2001, Ferrara et al. 2017). Thanks to these works, and to regional public fundings (PSR projects), there are currently about 300 fig accessions recovered and spread heterogeneously over the Puglia region, with a variable risk of genetic erosion or extinction (from very high to low) depending on the variety. Again, there are several cases of homonymy or synonymy, also confirmed by genetic analysis (Ferrara et al. 2017; Marcotuli et al. 2019). In Puglia, the main fig productions concern fruits for fresh consumption, especially brebas, which are already available, in the coastal areas, as early as June (in some seasons at the end of May), until the end of July in the inner areas. The most important varieties are “Petrelli,” early white-skinned, and “Domenico Tauro,” medium-late black-skinned, which, in addition to providing brebas, also produce good amounts of main crop after caprification (Ferrara et al. 2022). These varieties are managed in commercial fig orchards, with more intensive planting distances and often with irrigation systems needed in drier years or in the first few years after planting. In other Puglia areas, fig is found mainly in intercropping with other tree species (citrus, almond, vine, olive) and herbaceous (wheat, vegetables, legumes). Normally considering its ease of propagation, it is propagated by cuttings and planted directly in the field, or even using the suckers rooted in the winter period; only rarely grafting is used, which is usually by budding (inverted T) and in few cases with sticks. The most common and adopted training system is the vase with a short trunk to facilitate harvesting operations that are done

manually, from the branches that in many cases may touch the ground (Ferrara 1986).

#### Fig varieties for breba production in Puglia

“Petrelli” (SPt) (Fig. 5A), already described and studied by several authors (Capua 1988; Ferrara and Vendola 1990; Ferrara and Petruzzella 1991; Ferrara and Papa 2001; Ferrara et al. 2016; Limongelli and de Benedictis 1990; Minonne 2007) has been present in the Puglia since ancient times, also according to reports by Vallese (1909), Donno (1951) and later by Minonne et al. (2002). Selected in the province of Bari, close to the coastal area between Polignano a Mare and Monopoli, among the group of brebas known as “S. Antonio” (SPt), “S. Giovanni” (SPt), “Columbro” (SPt), “Culummone” (SPt), “Colummara bianca” (SPt), it has good earliness and productivity (Ferrara 1990; Minonne 2007, 2011). Vallese (1909) ascribes it to the variety “Colomba Bianca” (SPt) that is cultivated in the province of Brindisi. It is probably the most common variety in commercial plantings in the province of Brindisi, between Torre Canne and Polignano a Mare and much appreciated by consumers. The fruit has a spinning top shape and green skin, with weights that in some cases can reach up to 100 g, juicy, sweet flesh with purple hues. Productivity of this variety is medium–high, although it has low resistance to handling and shipping, and this is the major drawback. Main crop can be abundant in some seasons and used for fresh consumption but can be also used for drying or for processing.

The other important variety, grown in the areas north of the province of Bari (Ruvo di Puglia, Terlizzi, Corato), and partly in other areas (Monopoli, Salento), is “Tauro,” (SPt) (Fig. 5B) also known by the names “Minghtaur,” “Mango Tauro,” and “Domenico Tauro.” The location, the cooler and more inland areas, allow the fruit to ripen



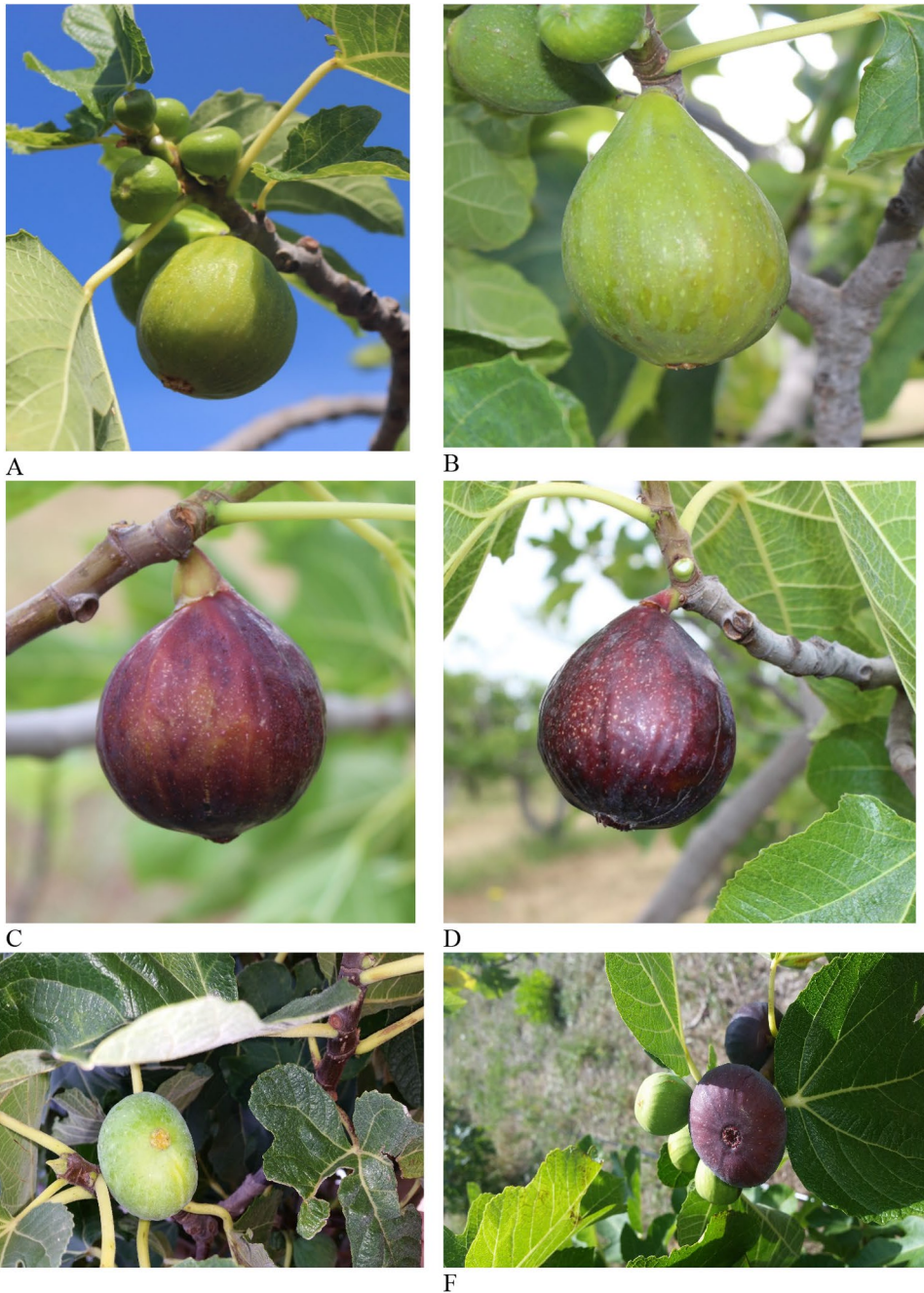
**Fig. 5** Green skinned brebas of the variety Petrelli (A) and red skinned brebas of the variety Domenico Tauro (B)



later than “Petrelli,” by about a 15–30 days (July). Its presence in Puglia is reported as early as 1700, when mayor Domenico Tauro selected it and later disseminated it (Cavallo 2013; Ferrara and Papa 2001; Ferrara et al. 2016). The first crop (brebas) is very abundant, with large (90 g) spinning top-shaped fruits, purplish skin and green hues that have longitudinal cracks when fully ripe. The flesh is medium sweet, nonaromatic, not very juicy with a deep

red color but it is prone to handling and shipping better than Petrelli. Main crop, not very abundant, for fresh consumption.

Other minor landraces quite present in Puglia with good production of brebas are “Fiorone bianco” (Fig. 6A), “Fiorone bianco Oria” (Fig. 6B), “Rosso Triggiano” (Fig. 6C), “Zingarello nero” (Fig. 6D), Fiorone Gioia (Fig. 6E), “Regina” (Fig. 6F), “Fiorone nero di Terlizzi”;



**Fig. 6** Brebas of Fiorone bianco (A), Fiorone bianco Oria (B), Rosso Triggiano (C), Zingarello nero (D), Fiorone Gioia (E) and Regina (F)

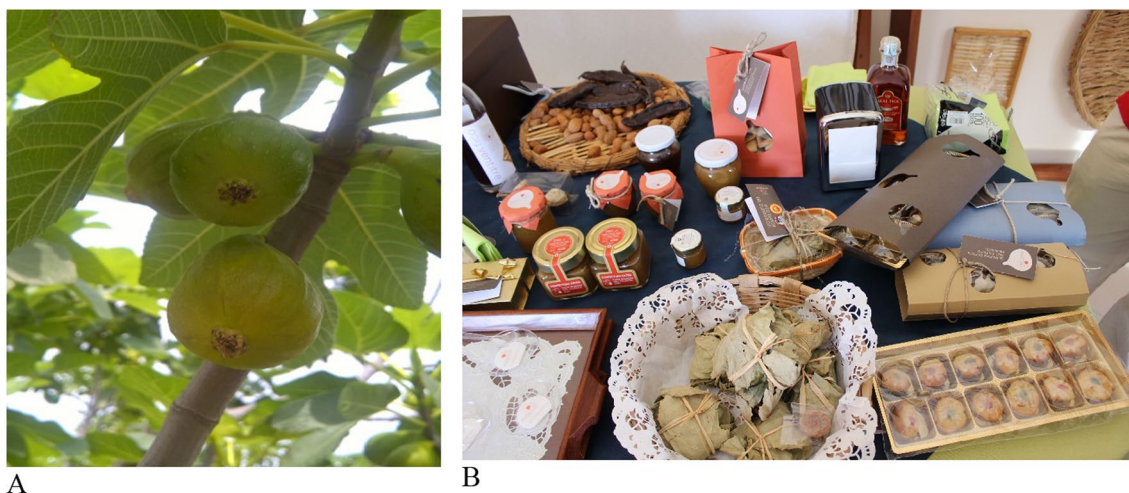
“Rosso commune”, “Rosso Oria”, “Rosso di Trani”, “Testa di gatto”, “Faraone” and “Troiano” that also provide fair amounts of main crop, consumed mainly fresh and are mainly located in the province of Bari. The variety “Nero di Terlizzi” (Ct) is cultivated in the northern province of Bari (Terlizzi, Ruvo di Puglia, Molfetta) and is derived from selection of a black “Culumbro” ecotype also present in that area, which is particularly productive, therefore used for commercial purposes. It provides good yields of brebas, but also main crops that are medium-sized, good texture, with little aromatic pink/orange flesh. It is also known as “Fiorone nero di Terlizzi” and “Columbro nero” (Ferrara et al. 1991, 2016). “Fiorone nero di Sava” is found in the province of Taranto and provides fruit with neutral flavor, medium size, red flesh and medium ripeness (late June) (Ferrara 1986; Ferrara and Papa 2001). Among the varieties grown in Salento are to be mentioned: “Casciteddha” (also known as “Albanera”), “Fracazzano bianco,” “Fracazzano nero,” “Culummo nero,” often confused in the province of Lecce with “Culummaro nero” or “Colombaro nero” and “Nero di Terlizzi,” which, however, represent different varieties (Vallese 1909), “Janculeddha” and “Culummo bianco” (Minonne et al. 2001). All these minor varieties differ from “Petrelli” and “Tauro” because they belong to the “common type” (Ct).

#### “Common type” and “Smyrna” type varieties in Puglia

Within the Puglia fig biodiversity, there are many varieties that despite valuable organoleptic characteristics are not widely cultivated due to drawbacks related to commercial aspects (limited shelf-life, poor resistance to handling and shipping, browning affecting the epicarp, poor texture, presence of cracks, stalk damage at harvest).

Certainly the “Dottato” (syn. “Kadota”) (Ct) (Fig. 7A) is the oldest and most widespread variety grown in Puglia, being well known in the country, since in two southern regions, Campania and Calabria, there are the Protected Designation of Origin (PDO) known as “Fico bianco” of Cilento and “Fico di Cosenza”, respectively, but is also well known and cultivated in many countries. It is essentially used for dried fig (the origin of the name comes from the Greek ‘optao’ means to dry), but it is often used for fresh consumption (Pavone et al. 2001) or for other processed products (Fig. 7B). The variety groups a set of ecotypes, which often have different vegetative-productive characteristics, as well as the aptitude to produce more or less brebas (Della Porta 1592; Polizzi 1873; D’Alessandro Picchi 1995; Galderisi et al. 2001). Brebas of Dottato have been described by several authors (Ferrara et al. 1991; Pavone et al. 2001), they present white/purple flesh, neutral, sweet flavor, and have medium to small size (50 g). Main crop is abundant, bearing fruit slightly smaller than brebas, with ripening in Puglia starting in late July and lasting until September (Siniscalchi 1912; Casella 1933; Baldini 1953; Grassi et al. 2001). The Dottato variety in Puglia is known by several synonyms: “Uttata,” “Nardoleo,” “Lumineddha,” “Bianculeddha,” “Vottata.” In northern Puglia (Gargano area), a black-skinned variety has been found (Biscotti and Biondi 2008; Biscotti et al. 2010), which is not present in the rest of the region and called Dottato nero.

Other minor varieties found in Puglia and highly appreciated are “Fico Signora” (Ct) (syn. “Della signora,” “Signora,”), with abundant main crops that have medium-late ripening (August–October) and purplish skin, and discrete brebas production (Guglielmi 1908; Vallese 1909; Donno 1952; Condit 1955; Grassi 1982; Trotta et al. 2013;



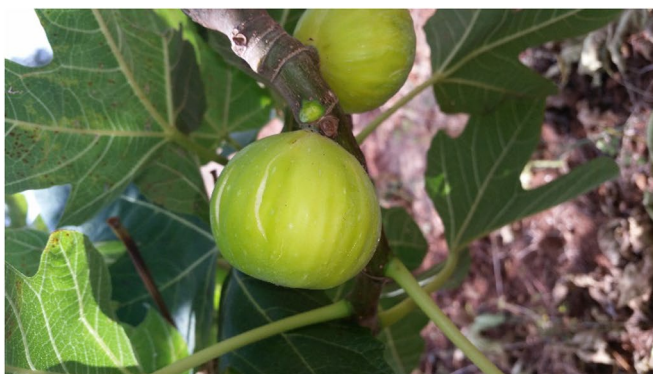
**Fig. 7** Dottato main crop (A) and processed products (B) obtained from the fruits (cookies, liquor, fruits in wine, jam, etc.)



Minonne 2017). The Abate variety (St) (syn. “Dell’Abate,” “Albachiara,” “Rapona”) is another variety located mainly in Salento that ripens late (August–September), produces only main crops that are large in size, with a green-yellow epicarp and white, sweet flesh. It is mainly used for fresh consumption and has good resistance to handling. Described by several authors (Guglielmi 1908; Vallese 1909; De Rosa 1911; Donno 1952; Condit 1955; Donno 1959; Grassi 1982; Minonne 2017), it is still cultivated and appreciated. In Salento (southern Puglia), numerous varieties are still present although some only in certain small areas and intended mostly for fresh consumption, but in many cases, they are also used for drying. Among those with white skin there is “Asprinia” (St) with light red, fine and sweet flesh and intermediate ripening (20–30 August) (Donno 1952), “Borsamele bianco” (St) with honeyed flesh from which the name is derived, at intermediate ripening (Donno 1952, 1959; Brunetti 1989; Grassi 1982; Minonne 2017), while “Borsamele nero” (St) has black skin and is localized mainly in the province of Brindisi (Donno 1952, 1959; Brunetti 1989; Grassi 1982; Suma and Venerito 2008; Trotta et al. 2013). “Casciteddha” (Ct) is another known variety also appreciated to produce brebas and described by several authors in the past (Vallese 1906; Guglielmi 1908; De Rosa 1911; Donno 1951; Condit 1955; Minonne 2017). Brebas, are large, with black skin and flattened shape, medium coloring, while main crop is abundant with skin that splits longitudinally when ripe. “Farà” is the main variety used in Salento for drying, with green-yellow skin; also known as “Pelosa” it has been described by several authors (Vallese 1909; Donno 1952, 1959; Condit 1955; Grassi 1982; Minonne 2017) and has good resistance to handling. “Fracazzano” (Ct) (also known as “Ficazzana”) banco, with a green skin (Fig. 8A), and nero, with a red skin (Fig. 8B), are also present in Puglia with several local ecotypes that also differ in fruit characteristics. Both

Fracazzano are biferous and produce fair quantities of brebas, and good quantities of main crop that are used for fresh consumption (Guglielmi 1908; Vallese 1909; De Rosa 1911; Mazzilli 1927; Donno 1948, 1951; Grassi 1982; Brunetti 1989; Ferrara and Vendola 1991).

Other varieties described in Salento are “Lancina” (Ct) (sin. Laccina) biferous, parthenocarpic and with green skin (Vallese 1909; Minonne 2017), “Lattarola” (St) (syn. Ritonna, Lattarula) uniferous, no parthenocarpic, green-skinned used for both fresh and dried consumption (Guglielmi 1908; Vallese 1909; Condit 1955; Suma and Venerito 2008; Minonne 2017), “Marangiana” (Ct) (syn. “Ottata rossa” or “Maranciana”) with purplish skin showing longitudinal cracks at maturity, uniferous, parthenocarpic, at medium maturity (mid-August) found especially on the coastal strip (Guglielmi 1908; Vallese 1909; De Rosa 1911; Donno 1952, 1959; Condit 1955; Ferrara and Papa 2001; Trotta et al. 2013; Ferrara et al. 2017; Minonne et al. 2017). Also fairly common in Salento are the following varieties: “Menunceddha” (Ct) (syn. Meloncella, Melonceddha), white-skinned with cracks at maturity, parthenocarpic, uniferous, with excellent flavor and resistance to handling (Guglielmi 1908; Vallese 1909; Condit 1955; Minonne 2017), “Natalegna nera” (Ct) (syn. Di Natale, Natalina, D’inverno, Vernea) and “Natalese Bianca” are late ripening varieties, both parthenocarpic and biferous, with ripening beginning in September and sometimes extending until November. “Panetta nera” (Ct) (syn. Panettara, or di S. Oronzo), uniferous, parthenocarpic, with purple skin and medium ripening (late August) (Guglielmi 1908; Vallese 1909; Minonne 2017). Among the most common varieties in Bari province we can list: “Procesotto” (Ct), white-skinned, uniferous, parthenocarpic, medium-ripening (mid-August) and resistant to handling (Vallese 1909; Condit 1955; Biscotti and Biondi 2008; Biscotti et al. 2010; Minonne 2017); “Regina” (Ct)



A



B

**Fig. 8** Main crops of Fracazzano bianco (A) and Fracazzano nero (B)

with green-purple skin, parthenocarpic, biferous, highly valued especially for main crop but with low resistance to manipulation and medium ripening (August), (Gallesio 1817; Stella 1857; Vallese 1909; Ferrara and Vendola 1986; Pace 1997; Trotta et al. 2013; Ferrara et al. 2017); “Ricotta” (Ct), so called because of the delicacy of its flesh (like the dairy product), has green-purple skin, uniferous, parthenocarpic, medium-late ripening (September) (Grassi 1984; Minonne 2011; Trotta et al. 2013). Another interesting variety grown throughout the region is “Zingarello bianco” (Ct) (syn. ‘Du acidd’, ‘Culumbr Zingaridd’, ‘Culumm Tunn’), with good production of brebas that ripen later than “Petrelli”, good size and flavor. There is also a dark-skinned variant called “Zingarello nero” (Ct) with juicy flesh and numerous small drupelets (Pantanelli 1936; Ferrara et al. 1991; Pace 1997; Pellegrino 2001; Minonne 2017; Trotta et al. 2013). A brief list of other varieties described in Puglia region is given in the Table 1.

#### Future perspectives

Fig cultivation can be a viable alternative because of the capacity and resilience this species has shown in hot and drought environments with some well adapted varieties. In addition, the increase in consumer demand and the

search for alternative/minor fruits could stimulate many farms to undertake the cultivation, taking advantage also of the high biodiversity that allows a diversification of products, with a wide ripening calendar, both for brebas and main crop. This would also allow, in Puglia, and in similar areas for pedo-climatic conditions, the cultivation of other varieties, apart from the most important ones, especially to produce brebas, which show interesting qualitative, health aspects and resistance to manipulation. The establishment of specialized orchards would allow for better management of agronomic aspects such as fertilization, weed control, pruning, and training system. The fig could be trained to espalier (cordon type) like grapevine, with a better management of the agronomical practices (pruning, harvesting). However, in the light of the first descriptive studies conducted on the fig over a century ago, several more recent ones are added, covering qualitative, productive, and agronomic aspects (fertilization, irrigation, caprification) which may represent useful information for technicians and farmers who want to undertake the cultivation of this species, albeit related to a limited number of varieties. There are many varieties with a potential to be used for breeding programs in order to obtain new varieties with a better handling, but for such programs good caprifigs should also

**Table 1** Varieties located and described in Puglia region with a potential for cultivation (fresh and/or processing)

Variety	Type	Location	References
A Sanguè	Smyrna	Brindisi province	Suma and Venerito (2008); Trotta et al. (2013); Minonne (2017)
Abbondanza	Common	Brindisi province	Suma and Venerito (2008); Minonne et al. (2011); Trotta et al. (2013); Minonne (2017)
Agostinella	Common	Foggia province	Biscotti and Biondi (2008); Biscotti et al. (2010)
Cervone	Common	Bari province	Trotta et al. (2013)
Citulara	Common	Lecce province	Vallese (1909); Condit (1955); Biscotti and Biondi (2008); Biscotti et al. (2010); Minonne (2017)
Coppa	Common	Salento (south Apulia)	Guglielmi (1908); Vallese (1909); Donno (1952); Condit (1955); Grassi (1982); Minonne (2017)
Della Croce	Common	Brindisi province	Minonne (2017)
Fonnole	Common	Lecce province	Pellegrino (2001); Locaputo (2010); Minonne (2017)
Laccia	Smyrna	Lecce province	Ferrara and Mazzeo (2015) (p.c.)
Martana	Common	Lecce province	Vallese (1909); Minonne (2017)
Mattepinto	Common	Bari province	Pellegrino (2001); Minonne (2011); Trotta et al. (2013)
Paccia	Common	Lecce province	Guglielmi (1908); Vallese (1909); De Rosa (1911); Donno (1952); Condit (1955); Minonne (2017)
Paradiso	Common	Puglia	Gasparrini (1845a, b); Stella (1857); Vallese (1909); Condit (1955); Biscotti and Biondi (2008); Biscotti et al. (2010); Minonne (2017)
Pasulita	Common	Lecce province	Guglielmi (1908); Vallese (1909); De Rosa (1911); Donno (1952); Condit (1955); Minonne (2017)
Potentino	Common	Lecce province	Vallese (1909); Donno (1951); Condit (1955); Minonne (2017)
Rizzeddha	Common	Lecce province	Vallese (1909); De Rosa (1911); Mazzilli (1927); Condit (1955); Ferrara and Dell’Atti (1998); Minonne (2017)
Sessa	Common	Lecce province	Vallese (1909); De Rosa (1911); Mazzilli (1927); Donno (1952); Condit (1955); Trotta et al. (2013); Minonne (2017)
Tarantina	Common	Puglia	Vallese (1909); Minonne (2017)
Vastesana	Common	Bari province	Pantanelli (1936); Grassi (1984); Pellegrino (2001); Locaputo (2010); Trotta et al. (2013)
Verdesca	Common	Brindisi province	Gasparrini (1845a, b); Vallese (1909); Mazzilli (1927); Condit (1955); Donno (1959); Grassi (1984); Minonne et al. (2011); Trotta et al. (2013); Minonne (2017)

be selected. This review showed only a little part of the potential biodiversity of fig in Puglia region which should be preserved but also should live in orchards for producing fresh and processed (new) products.

#### Author contributions

AMaz screened the literature for relevant references, produced all graphs, added pictures and wrote the first draft. GF and AMag reviewed and edited the draft and GF added other pictures. All authors read and approved the final submitted manuscript.

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#### Availability of data and materials

On request.

#### Declarations

#### Ethics approval and consent to participate

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#### References

- Abdelsalam NR, Awad RM, Ali HM, Salem MZM, Abdellatif KF, Elshikh MS. Morpho- logical, pomological and specific molecular marker resources for genetic diversity analyses in fig (*Ficus carica* L.). *HortScience*. 2019;54:1299–309. <https://doi.org/10.21273/HORTSCI14091-19>.
- Aksoy U. Why figs? An old taste and a new perspective. *Acta Hort*. 1998;480:25–7.
- Aljane F. Caractérisation et évaluation des accessions locales de figuier (*Ficus carica* L.) en Tunisie et selection des plus performantes. MSc Thesis, Faculté des Sciences de Tunis, Tunisie. 2011.
- Aljane F, Ferchichi A. Assessment of genetic diversity among some southern Tunisian fig (*Ficus carica* L.) cultivars based on morphological descriptors. *Jordan J Agric Sci*. 2009;5(1):1–15.
- Aljane F, Nahdi S. Propagation of some local fig (*Ficus carica* L.) cultivars by hardwood cuttings under the field conditions in Tunisia. *Int Sch Res Not*. 2014;2014:5. <https://doi.org/10.1155/2014/809450>.
- Aljane F, Nahdi S, Essid A. Genetic diversity of some accessions of Tunisian fig tree (*Ficus carica* L.) based in morphological and chemical traits. *J Nat Prod Plant Resour*. 2012;2:350–9.
- Almajali D, Abdel-Ghani AH, Migdadi H. Evaluation of genetic diversity among Jordanian fig germplasm accessions by morphological traits and ISSR markers. *Sci Hortic*. 2012;147:8–19. <https://doi.org/10.1016/j.scientia.2012.08.029>.
- Armstrong WP. Sex life of fig: coevolution of a tree & minute wasp (Part.1). 2012.
- Baldini E. Alcuni aspetti della coltura del fico nella provincia di Firenze. Riv Ortoflorofruitticoltura Ital. 1953;7–8:185–203.
- Baldini E. Agrumi, frutta e uve nella Firenze di Bartolomeo Bimbi pittore medico. Firenze: Parretti Grafiche; 1982. p. 71–8.
- Baldini E and Tosi A. (1994). *Scienza ed Arte nella Pomona Italiana* di Giorgio Galesio. Accademia dei Georgofili, ed. Polistampa, Firenze. p. 132.
- Bauhin K. *Pinax theatri botanici*. Basiliae: Ludovici Regis; 1623.
- Beck N, Lord E. Breeding system in *Ficus carica*, the common fig. I. the flora diversity. *Amer J Bot*. 1988;75:1904–12.
- Ben Abdelkrim A, Baraket G, Essalouh L, Achantak H, Khadari B, Salhi-Hannachi A. Use of morphological traits and microsatellite markers to characterize the Tunisian cultivated and wild figs (*Ficus carica* L.). *Biochem Syst Ecol*. 2015;59:209–19. <https://doi.org/10.1016/j.bse.2015.01.026>.
- Berg CC. Flora malesiano precursor for the treatment of Moraceae 1: the main subdivision of *Ficus*: the subgenera. *Blumea*. 2003;48:167–78.
- Biscotti N, Biondi E. I frutti antichi del Gargano, un tesoro irripetibile a rischio di rapida estinzione. *Biodiversità italiana, trimestrale Min. Ambiente e tutela del territorio e del mare*. Anno 2, n. 2. 2008.
- Biscotti N, Guidi S, Forconi V, Piotto B. I frutti dimenticati e biodiversità recuperata. Ispra, Roma. 2010.
- Boudchicha RH, Hormaza JI, Benbouza H. Diversity analysis and genetic relationship among local Algerian fig cultivars (*Ficus carica* L.) using SSR markers. *South Afr J Bot*. 2018;116:207–15. <https://doi.org/10.1016/j.sajb.2018.03.015>.
- Brunetti P. (1989). *Vocabolario essenziale, pratico ed illustrato del dialetto manduriano*. Ed. Barbieri Selvaggi, Manduria.
- Caliskan O, Polat AA. Fruit characteristics of fig cultivar and genotypes grown in Turkey. *Scientia Horticulturae* 2008;115:360–67.
- Caliskan O, Polat AA. Effects of genotype and harvest year on phytochemical and fruit quality properties of Turkish fig genotypes. *Span J Agric Res*. 2012;10:1048–58.
- Caliskan O, Bayazit S, Ilgin M, Karatas N, Ergul A. Genetic diversity and population structure in caprifigs (*Ficus carica* var. *caprificus*) using SSR markers. *Span J Agric Res*. 2018;16: e0703. <https://doi.org/10.5424/sjar/2018163-11662>.
- Capua E. Situazione attuale, problemi e prospettive della coltura del fico in Italia, con particolare riguardo alla provincia di Viterbo. Contributo sperimentale alla individuazione di presunti cloni delle varietà presenti in provincia. Università degli Studi di Firenze, Facoltà di Scienze agrarie e forestali, Anno accademico 1987/1988. 1988.
- Casella D. Il Dottato nell’industria dei fichi secchi. *Annali della Real Stazione Sperimentale di frutticoltura e di agrumicoltura, Acireale*: 57–sgg. 1933.
- Cavallo C. I fioroni ed i fichi: caratteristiche e tipicità delle produzioni pugliesi. Edizioni COBEGA, Capurso (Ba). 2013.
- Celi G. Ricerche sulla biologia e filogenesi del fico ed inquadramento delle relative razze italiane meridionali (*Ficus carica* L.). Napoli. *Atti del reale Istituto di Incoraggiamento di Napoli*, 1907;4(6): 541–654.
- Chessa I, Di Cintio L, Laudadio M, Minonne F. *Atessa e i fichi secchi ‘Li caracine’*. Ed. Tinari, Villamagna (CH). 2014. p. 128.
- Ciarmiello LF, Piccirillo P, Carillo P, De Luca A, Woodrow P. Determination of the genetic relatedness of fig (*Ficus carica* L.) accessions using RAPD fingerprint and their agro-morphological characterization. *S Afr J Bot*. 2015;97:40–7. <https://doi.org/10.1016/j.sajb.2014.11.012>.
- Condit IJ. The structure and development of flowers in *Ficus carica* L. *Hilgardia*. 1932;6:443–81.
- Condit IJ. The fig. Massachusetts: *Chronica Botanica* Waltham; 1947.
- Condit IJ. Fig varieties: A monograph. *Hilgardia* 1955;23:323–538.
- Crisosto CH, Bremer V, Ferguson L, Crisosto GM. Evaluating quality attributes of four fresh fig (*Ficus carica* L.) cultivars harvested at two maturity stages. *HortScience*. 2010;45:707–10.
- Crisosto CH, Ferguson L, Bremer V, Stover E, Colelli G. Fig (*Ficus carica* L.). In: Yahia EE, editor. *Postharvest biology and technology of tropical and subtropical fruits*. Fruits 3. Cocona to Mango. Cambridge: Woodhead Publishing Ltd.; 2011. p. 134–58.
- D’Alessandro E, Picchi G. Il Fico del Cilento. In *Prodotti agro-alimentari tipici della Campania*. Portici, Luglio. 1995. p. 195–227.
- Datwyler SL, Weiblen GD. On the origin of the fig: phylogenetic relationships of Moraceae from *ndh F* sequences. *Am J Bot*. 2004;91:767–77.
- Della Porta GB. Villa. (di lo. Baptistae Portae). 1592;12: 914. (De ficu: 300–327).
- Donno G. Il Fico nel Salento. *L’Agricoltura meridionale*, Napoli. 1948;A1:12.



- Donno G. Alcune varietà unifere di Fico coltivate in provincia di Lecce. Annali Facoltà di Agraria di Napoli, Portici serie III, 1951;XIX: 89:106.
- Donno G. Constatazioni e considerazioni sul biferismo del Fico. Annali Facoltà di Agraria di Napoli, Portici, serie III. vol. XXIX. 1952.
- Donno G. Il Fico. Estratto dagli Annali della Facoltà di Agraria dell'Università di Bari. 1959; XIII: 1–31.
- Donno G. Sul polimorfismo e sulla xerofilia del *Ficus carica* L. Ann Fac Agraria Bari. 1972;XXV: 538–60.
- FAO/STAT. Food and Agriculture Organization of the United Nations. 2024. <https://www.fao.org/faostat/en/#home>. Accessed 3 May 2024.
- Ferrara E. La coltura del fico in Puglia: stato attuale e prospettive. Notiziario Agricolo Regionale. 1986;10:1–7.
- Ferrara E, dell'Atti G. Alcune varietà di fico diffuse nel Brindisino. L'Informatore Agrario N. 1998;49:63–9.
- Ferrara E, Papa G. Germoplasma fico: caratterizzazione morfologica di 30 cultivar per la produzione di fiori. In: VI Convegno Nazionale della Biodiversità, Bari, 6–7. 2001.
- Ferrara E, Petruzzella D. Valutazioni fenolo-carpologiche del patrimonio varietale del Fico raccolto in Puglia, nota II. Frutticoltura. 1992;6:63–6.
- Ferrara E, Vendola D. Osservazioni preliminari su tredici cultivar di fico diffuse in Puglia. In: Atti "Convegno nazionale sul fico", Vallo della Lucania (SA), 12 Luglio. "Agricoltura e Ricerca" Anno XII, n. 112–113, agosto-settembre, 1990. 1986; p. 31–8.
- Ferrara E, Vendola D. Il Fico: Tredici cultivar diffuse in Puglia. In: Atti del I Convegno nazionale sul Fico, Vallo della Lucania (Sa), 1986. Agricoltura e Ricerca, anno XII n. 112–113- nuova serie, agosto-settembre: 31–38. 1990.
- Ferrara E, Petruzzella D, Guida F. Prime valutazioni agronomiche del patrimonio varietale del fico (*Ficus carica* L.) raccolto in Puglia, Nota I L'Informatore Agrario. 1991;XLVII(28): 59–63
- Ferrara G, Mazzeo A, Pacucci C, Matarrese AMS, Tarantino A, Crisosto C, Incerti O, Marcotuli I, Nigro D, Blanco A, Gadaleta A. Characterization of edible fig germplasm from Puglia, Southern Italy: Is the distinction of three fig types (Smyrna, San Pedro and Common) still valid? Sci Hortic. 2016;205:52–8.
- Ferrara G, Mazzeo A, Gallotta A, Pacucci C, Matarrese AMS, Tarantino A, Incerti O, Marcotuli I, Nigro D, Blanco A, Gadaleta A. Fruit-set and SSR markers of fig cultivars from Puglia region, Southeastern Italy. Acta Hortic. 2017;1173:7.
- Ferrara G, Magarelli A, Giannoccaro G, Mazzeo A. Coltivazione del fico marginalità interessanti con i giusti sbocchi commerciali. Rivista di Frutticoltura. 2022;5:58–64.
- Ferrara G, Magarelli A, Mazzeo A, Coletta A, Crupi P, Loperfido F, Maggi G, Venerito P. Underutilized fig (*Ficus carica* L.) cultivars from Puglia region, Southeastern Italy, for an innovative product: dried fig disks. Processes. 2023;11(5):1485. <https://doi.org/10.3390/pr11051485>.
- Ferraro C. Giorgio Gallesio (1772–1839), vita, opere, scritti e documenti inediti. Firenze: Accademia dei Georgofili; 1996.
- Ferrara and Mazzeo 2015 (personal communication).
- Flaishman MA, Rover V, Stover E. The fig: botany, horticulture and breeding. Hort Rev. 2008;34:113–97.
- Gaaliche B, Saddoud O, Mars M. Morphological and pomological diversity of fig (*Ficus carica* L.) cultivars in northwest of Tunisia. ISRN Agronomy. 2012. p. 1–9.
- Galderisi G, Di Bernardo G, De Masi L, Galano G, Cascino A, Cipollaro M, Pavone E, Grassi G. Caratterizzazione molecolare e selezione clonale del fico (*Ficus carica* L.) "Dottato" mediante RAPD-PCR. Atti 2° Convegno Nazionale sul Fico, "Fico essiccato, innovazione e qualità". Ascea Marina (SA) 9 ottobre. Italus Hortus, vol 8, suppl. al n. 5, sett/ott: 20–21. 2001.
- Galil J. Fig biology. Endeavour. 1977;1:52–6.
- Galil J, Eisikowitch D. Flowering cycles and fruit types of *Ficus sycomorus* in Israel. New Phytol. 1968;67:745–58.
- Galil J, Neeman G. Pollen transfer and pollination in the common fig (*Ficus carica* L.). New Phytol. 1977;79:163–71.
- Gallesio G. Pomona Italiana, presso Nicolò Capurro, Pisa. 1817.
- Gasparrini G. Raggiungimento agricoltura e pastorizia nel Regno di Napoli. Tip. Del Filiale Sabezio, Napoli. 1845a.
- Gasparrini G. Ricerche sulla natura del caprifico e del fico e sulla caprificazione. Articolo estratto dal n. 23 del Rendiconto della R. Accademia delle Scienze di Napoli. Napoli, Tip. Dell'Aquila di V. Puzziello. 1845b.
- Gozlekci S. Selection studies on fig (*Ficus carica* L.) in Antalya Province of Turkey. Afr J Biotech. 2010;9:7857–62. <https://doi.org/10.5897/AJB10.1382>.
- Grassi G. Il Fico: Una coltura interessante per molte zone della Puglia. Frutticoltura anno XLIV n. 9–10. 1982.
- Grassi G. Dizionario martinese italiano. Fasano: Schena; 1984.
- Grassi G. Stato attuale e problematiche della coltura del fico in Italia. Atti del I Convegno Nazionale sul Fico, Vallo della Lucania (SA) 12 luglio 1986. Agricoltura e Ricerca Speciale Fico, N. 1990;112–113:9–14.
- Grassi G. Il Fico. Collana manuali pratici. Ed. Reda, Roma, 1991. p. 128.
- Grassi G, Simeone A, Di Matteo M, Albanese A. Tipicizzazione e certificazione del prodotto Fico essiccato italiano. In: Atti del 2° Convegno Nazionale sul Fico, Ascea Marina (SA), 9 ottobre 2001. Italus hortus Vol. 8 suppl. n. 5, sett-ott 2001. p. 89–91.
- Guglielmi G. Coltivazione industriale del fico nel Leccese, memoria monografica. 1908.
- Haffar S, Ben Abdelkrim A, Salhi-Hannachi A, Baraket G. Genetic diversity assessment of Tunisian fig (*Ficus carica* L.) using conserved DNA-derived polymorphism. Acta Hort. 2017;1173:51–6. <https://doi.org/10.17660/ActaHortic.2017.1173.9>.
- Harzallah A, Bhouiri AM, Amri S, Soltana H, Hammami M. Phytochemical content and antioxidant activity of different fruit parts juices of three figs varieties grown in Tunisia. Ind Crops Prod. 2016;83:255–67. <https://doi.org/10.1016/j.indcrop.2015.12.043>.
- Hoxha L, Kongoli R. Evaluation of antioxidant and potential of Albanian fig varieties "Krapis Zi" and "Krapis Bardhe" cultivated in the region of Tirana. J Hyg Eng Des. 2016;16:70–4.
- ISTAT. 2024. <http://dati.istat.it/#>. Accessed 3 May 2024.
- Janzen IH. How many babies do fig pay for babes? Biotropica. 1979;11:48–50.
- Jona B, Gribaudo I. *Ficus* spp. In: Baja YPS, editor. Biotechnology in agriculture and forestry, vol. 16. Trees III. Berlin: SpringerVerlag; 1991. p. 76–93.
- Kislev ME, Hartmann A, Bar-Yosef O. Early domesticated fig in the Jordan Valley. Science. 2006;312:1372–4.
- Kjellberg F, Gouyon PH, Ibrahim M, Raimond M, Valdeyron G. The stability of symbiosis between dioecious fig and their pollinator: a study of *Ficus carica* L. and *Blastophaga psenes* L. Evolution. 1987;41:693–704.
- Lianju W, Weibin J, Kai M, Zhifeng L, Yelin W. The production and research of fig (*Ficus carica* L.) in China. Acta Hortic. 2003;605:191–6.
- Limongelli F, De Benedictis R. Caratteristiche fenolo-carpologiche di 15 cultivar di fico per la produzione di fiori. In: Atti del I Convegno Nazionale sul Fico Vallo della Lucania (SA) 12 luglio 1986. In: Agricoltura e Ricerca Speciale Fico n. 112/113. 1990. p. 89–102.
- Lopacuto P. Dizionario della parlata conversanese. Bari: Levante Editori; 2010.
- Lumare D. Caratterizzazione mediante marcatori molecolari di alcune cultivar di *Ficus carica* L. diffuse nel Salento. Dottorato di ricerca in Ecologia Fondamentale XIX Ciclo, Università del Salento. 2007.
- Maghsoudlou E, Kenari RE, Amiri ZR. Evaluation of antioxidant activity of fig (*Ficus carica*) pulp and skin extract and its application enhancing stability of canola oil. J Food Process Preserv. 2017;41:1–11. <https://doi.org/10.1111/jfpp.13077>.
- Marcotuli I, Mazzeo A, Nigro D, Giove S, Giancaspro A, Colasuonno P, Prgommet Z, Prgommet I, Tarantino A, Ferrara G, Gadaleta A. Analysis of genetic diversity of *Ficus carica* L. (Moraceae) collection using simple sequence repeat (SSR) markers. Acta Sci Pol Hortor Cultus. 2019;18:93–109. <https://doi.org/10.24326/asphc.2019.4.9>.
- Marcotuli I, Mazzeo A, Colasuonno P, Terzano R, Nigro D, Porfido C, Tarantino A, Aiese Cigliano R, Sanseverino W, Gadaleta A, Ferrara G. Fruit development in *Ficus carica* L.: morphological and genetic approaches to fig buds for an evolution from monoecy toward dioecy. Front Plant Sci. 2020;11:1208. <https://doi.org/10.3389/fpls.2020.01208>.
- Marcotuli I, Mandrone M, Chiochio I, Poli F, Gadaleta A, Ferrara G. Metabolomics and genetics of reproductive bud development in *Ficus carica* var. sativa (edible fig) and in *Ficus carica* var. caprificus (caprifig): similarities and differences. Front Plant Sci. 2023a;14:1192350. <https://doi.org/10.3389/fpls.2023.1192350>.
- Marcotuli I, Giove SL, Giancaspro A, Gadaleta A, Ferrara G. Dataset from RNAseq analysis of bud differentiation in *Ficus carica*. Data Brief. 2023b;50: 109418. <https://doi.org/10.1016/j.dib.2023.109418>.
- Mars M. La culture du grenadier (*Punica granatum* L.) et du figuier (*Ficus carica* L.) en Tunisie. Cahiers Options Mediterr. 1995;13:85–95.
- Mata Parreño C, Badal Garcia E, Collado Mataix PP, Ripolles A. Flora iberica. De lo real a l'imaginario. Servicio de Investigación Prehistórica. Serie de Trabajos Varios, N. 111. Diputació de Valencia, Valencia, Spain. 2010.

- Mazzilli F. L'industria dei fichi secchi nel Tarantino. Tipografia Il Popolo Jonico, Taranto. 1927.
- Melgarejo P. El cultivo de la higuera (*Ficus carica* L.). In *Frutales de Zonas Áridas*; A. Madrid Vicente, Ediciones: Orihuela, Spain; 2017. p. 118.
- Melgarejo P, Sánchez M, Hernández F, Martínez J. Chemical and morphological characterization of four fig tree cultivars (*Ficus carica* L.) grown under similar culture conditions. *Int Soc Hortic Sci*. 2003;605:33–6.
- Meziant L, Saci F, Bachir Bey M, Louaiche M. Varietal influence on biological properties of Algerian light figs (*Ficus carica* L.). *Int J Bioinf Biomed Eng*. 2015;1:237–43.
- Minonne F. Varietà frutticole tradizionali del Salento–Biodiversità, conservazione, valorizzazione. Tesi di dottorato di Ricerca XX Ciclo Università degli Studi del Salento (Lecce). 2007.
- Minonne F. I nomi e le piante per una storia delle varietà agrarie del Salento, Provincia di Lecce–Mediateca, Progetto IDIESSE (Emeroteca Digitale Salentina) a cura di IMI GO, Lecce. 2008.
- Minonne F. Nel giardino dei “frutti minori”. Il Fico: tra memoria e valore attuale. Masseria Ficazzana. Salve, Lecce. 2009. [http://www.masseriaficazzana.it/il\\_valore\\_del\\_fico.asp](http://www.masseriaficazzana.it/il_valore_del_fico.asp). Accessed 12 Jun 2024.
- Minonne F. Varietà frutticole tradizionali del Salento. Biodiversità, Conservazione, Valorizzazione. Grafiche Giorgiani, Castiglione d'Otranto (Le). 2017.
- Minonne F, Ippolito F, Marchiori S. L'attività dell'Orto Botanico di Lecce nel reperimento e nella propagazione delle vecchie cultivar di *Ficus carica* L. Atti del II Convegno Nazionale sul Fico, Ascea Marina (SA) 9 ottobre 2001. In *Italus Hortus* vol. 8 supplemento al n. 5 sett/ott. 30–33. 2001.
- Minonne F, Ippolito F, Vincenti E, Marchiori S. Work carried-out by the Botanical Garden to find and propagate old cultivars of *Ficus carica* L. *Cahiers Options Méditerranéennes-CIHEAM/IAMB*. 2002.
- Minonne F, Belloni P, Biscotti N. Fichi di Puglia: storia, paesaggi, biodiversità, conservazione del fico in Puglia. Le Varietà. Coop. Ulisside Editore, Grafiche Giorgiani, Castiglione d'Otranto (Le). 2011.
- Morales J, Gil J. Fruit as staple food: the role of fig (*Ficus carica* L.) during the pre-hispanic period of the Canary Islands, Spain (from the 3rd–2nd Centuries BCE to the 15th Century CE). In: Chevalier A, Marinova E, Pena-Chocarro L, editors. *Plants and people—choices and diversity through time*, vol. 1. Oxford: Oxbow Books; 2014. p. 182–210.
- Ouchemoukh S, Hachoud S, Boudraham H, Mokrani A, Louaiche H. Antioxidant activities of some dried fruits consumed in Algeria. *Food Sci Technol*. 2012;49:329–32. <https://doi.org/10.1016/j.lwt.2012.07.022>.
- Pace N. Dialecto e cultura contadina a Bitonto. Bitonto: Centro Ricerche di Storie e Arte; 1997.
- Pantanelli E. La Frutticoltura in Terra di Bari. Bari: G. Laterza e figli; 1936.
- Pavone E, Scaglione A, Pagliaro A. Salvaguardia del patrimonio genetico di 13 cultivar di fico diffuse in provincia di Cosenza. In: Atti del II Convegno Nazionale sul Fico Ascea Marina (SA) 9 ottobre 2001. In *Italus Hortus* vol. 8 supplemento al n. 5 sett/ott.: 25–29. 2001.
- Pellegrino N. Dizionario castellanese. Fasano: Schena; 2001.
- Pereira C, Martín A, López-Corrales M, de Córdoba MG, Galván AI, Serradilla MJ. Evaluation of the physicochemical and sensory characteristics of different fig cultivars for the fresh fruit market. *Foods*. 2020;9:619.
- Perez-Jiménez M, López B, Dorado G, Pujadas-Salvá A, Guzmán G, Hernandez P. Ana-lysis of genetic diversity of southern Spain fig tree (*Ficus carica* L.) and reference materials as a tool for breeding and conservation. *Hereditas*. 2012;149:108–13. <https://doi.org/10.1111/j.1601-5223.2012.02154.x>.
- Polizzi L. *Agricoltura pratica ad uso del Colono*. 1873.
- Pontedera G. *Anthologia, sive de floribus natura*. Typ. Seminarii, Patavii. 1720.
- Ramirez WB. Coevolution of *Ficus* and Agaonidae. *Ann Mo Bot Gard*. 1974;61:770–80.
- Roda M, Roda G. *Manual del frutticoltore italiano*. Torino: Roma; 1881. p. 237–49.
- De Rosa F. Di alcune fiche salentine. R. Istituto d'Incoraggiamento di Napoli. Atti (sr 6) 9. 1911.
- Sadder MT, Ateyyeh AF. Molecular assessment of polymorphism among local Jordanian genotypes of the common fig (*Ficus carica* L.). *Sci Hortic*. 2006;107:347–51.
- Saddoud O, Chatti K, Salhi-Hannachi A, Mars M, Rhouma A, Marrakchi M, Trifi M. Gen-etic diversity of Tunisian figs (*Ficus carica* L.) as revealed by nuclear microsatellites. *Hereditas*. 2007;144:149–57. <https://doi.org/10.1111/j.2007.0018-0661.01967.x>.
- Salhi-Hannachi A, Chatti K, Saddoud O, Mars M, Rhouma A, Marrakchi M, Trifi M. Genetic diversity of different Tunisian fig (*Ficus carica* L.) collections revealed by RAPD fingerprints. *Hereditas*. 2006;143:15–22.
- Sarkosh A, Yavary A, Ferguson L. The fig: botany, production and uses. Wallingford: CABI; 2022. <https://doi.org/10.1079/9781789242881.0000>.
- Sinha KK. Figs. In: Caballero B, editor. *Encyclopedia of food sciences and nutrition*. Cambridge: Academic Press; 2003. p. 2394–9.
- Siniscalchi A. La coltivazione del fico nel Cilento. *Bollettino di Arboricoltura Italiana*. 1912.
- Slavin JL. Figs: past, present, and future. *Nutr Today*. 2006;41:180–4.
- Solomon A, Golubowicz S, Yablowicz Z, Grossman S, Bergman M, Gottlieb HE, Flaishman MA. Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica*). *J Agric Food Chem*. 2006;54:7717–23. <https://doi.org/10.1021/jf060497h>.
- Stella G. Catalogo delle piante che si coltivano nell'Orto Agrario della Società Economica della Provincia di Terra d'Otranto. *Giornale di Economia Rurale, Terra D'ottranto*. 1857;1:99–107.
- Storey WB. Figs. In: Janick J, Moore JN, editors. *Advances in fruit breeding*. West Lafayette: Purdue University Press; 1975. p. 568–89.
- Stover E, Aradhyia M, Ferguson L, Crisosto CH. The fig: overview of an ancient fruit. *HortScience*. 2007;42:1083–7.
- Suma F, Venerito P. Ceglie Messapica terra di biodiversità, illustrazione delle varietà da frutto locali. Ceglie Messapica (Br). 2008.
- Targiotti-Tozzetti A. Cenni storici sull'introduzione di varie piante nell'agricoltura ed orticoltura Toscana. Firenze: Tipografia galileiana; 1853. p. 181–6.
- Trad M, Le Bourvellec C, Gaaliche B, Renard MGC, Mars M. Nutritional compounds in figs from the southern Mediterranean region. *Int J Food Prop*. 2014;17:491–9.
- Trichopoulou A, Vasilopoulou E, Georga K, Soukara S, Dilis V. Traditional foods: why and how to sustain them. *Trends Food Sci Technol*. 2006;17:496–504.
- Trotta L. *La biodiversità delle colture pugliesi*. Bari: Italgrafica Sud; 2013.
- Valdeyron G, Lloyd DG. Sex differences and flowering phenology in the common fig *Ficus carica*. *Evolution*. 1979;33:673–85.
- Vallejo F, Marin JG, Tomas-Barberan FA. Phenolic compound content of fresh and dried figs (*Ficus carica* L.). *Food Chem*. 2012;130:485–92. <https://doi.org/10.1016/j.foodchem.2011.07.032>.
- Vallese F. I migliori fichi della nostra regione. Lecce: L'Agricoltura Salentina; 1906.
- Vallese F. *Il Fico*. Catania: Libreria editrice Concetto Battiato di; 1909.
- Veberic R, Colaric M, Stampar F. Phenolic acids and flavonoids of fig fruit (*Ficus carica* L.) in northern Mediterranean region. *Food Chem*. 2008;106:153–7. <https://doi.org/10.1016/j.foodchem.2007.05.061>.
- Vinson JA. The functional food properties of figs. *Cereal Foods World*. 1999;44:82–7.
- Vinson JA, Zubik L, Bose P, Samman N, Proch J. Dried fruits: excellent in vitro and in vivo antioxidants. *J Am Coll Nutr*. 2005;24:44–50.
- Viuda-Martos M, Barber X, Perez-Alvarez JA, Fernandez-Lopez J. Assessment of chemical, physico-chemical, techno-functional and antioxidant properties of fig (*Ficus carica* L.) powder co-products. *Ind Crops Prod*. 2015;69:472–9. <https://doi.org/10.1016/j.indcrop.2015.03.005>.
- Watson L, Dallwitz MJ. The families of flowering plants: descriptions, illustrations, identification, and information retrieval. 2004. <http://biodiversity.uno.edu/delta>. Accessed 12 Jun 2024.
- Weiblen GD. Phylogenetic relationships of functional lydioicious *Ficus* (Moraceae) based on ribosomal DNA sequences and morphology. *Am J Bot*. 2000;87:1342–57.
- Yemis O, Bakkalbas E, Artık N. Changes in pigment profile and surface colour of fig (*Ficus carica* L.) during drying. *Int J Food Sci Technol*. 2012;47:1710–9. <https://doi.org/10.1111/j.1365-2621.2012.03025.x>.
- Yialmaz S, Gozlekci S, Ersoy N. A review of fig sector in Turkey. *Acta Hort*. 2017;1173:409–14.
- Zohary D, Hopf M. *Domestication of plants in the old world*. 3rd ed. New York: Oxford University Press; 2000.
- Zohary D, Spiegel-Roy P. Beginnings of fruit growing in the old World. *Science*. 1975;187(3):19327.

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