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Saffron growing in Italy: a sustainable secondary activity for farms in hilly and sub-mountain areas

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ABSTRACT

Italy has faced a renewed interest in the production of saffron (*Crocus sativus* L.) in recent times. However, little is known about the status of this agri-food chain. This exploratory study investigates saffron production (from agronomic to social and marketing aspects) in Italy through 162 interviews with farmers. A large part of them (38%) are young, often at a higher level of literacy (bachelor or master) and new entrants in the agricultural sector (data significantly higher than the average for Italian farms). In more than half the cases, saffron production is considered a complementary activity, with an average production of 332 g per farm per year. Saffron farms are spread throughout Italy and are generally located in hilly/sub-mountain areas (between 143 and 703 m a.s.l.). Only 1% of farmers use agrochemicals, and more than 90% do not need irrigation, while just 40% of farms are mechanized, saffron can then be considered a low-input and sustainable choice for farms in marginal areas. Farmers focus on a high-quality product, certified by quality and sustainability labels. However, supply chain coordination, and knowledge and innovation support should be further developed to promote this sustainable production.

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Introduction

Cultivation of saffron in Italy followed the trend of land abandonment during the World War II, fading from 300 ha in 1910 to 60 ha around the 2000s (Gresta et al., 2008), despite its long tradition of production in the Italian peninsula. However, there is an apparent increase of interest in the cultivation of saffron in recent decades, also in less traditional areas for saffron production (such as Northern Italy) (Giorgi & Scheurer, 2015, 2017; Manzo et al., 2015) and in marginal areas. Nonetheless, there are no recent data on this trend. This research work aims to investigate some agronomic, social, and marketing aspects of the saffron production chain in Italy.

Saffron is a spice derived from the dried stigmas (female part or pistil) of the flower of *Crocus sativus*

L., a geophyte plant of the Iridaceae family. Stigmas are sold as such or powdered after being dried, and saffron has remained among the world's most costly substances throughout history. With its bitter taste, hay-like fragrance, and slight metallic notes, saffron has been used historically as a seasoning, fragrance, dye, and medicine. Today as well, the spice is the most expensive worldwide (Winterhalter & Straubinger, 2000) and it is mainly used in the food sector but also in the textiles dyeing industries and in cosmetics production (Basker & Negbi, 1983). Currently, this spice is seeing an increasing demand due principally to Asian population growth (Arslanalp et al., 2019) and to the fashion of Asian cooking worldwide.

The high requirement of meticulous manual operations to produce this spice fixes its high cost. In fact,

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flowers of *C. sativus* must be picked before they are exposed to sunlight; stigmas must be carefully divided from the rest of the flower and dried at a low temperature (less than 50°C) or through a very fast drying process at higher temperature; furthermore, this work is concentrated on a few days a year and on a few hours a day, and all the other activities (field preparation, corms planting, weeding, etc.) are performed mostly by hand (Husahini et al., 2010; Leoni et al., 2022).

The history of saffron cultivation and usage reaches back more than 3000 years (Shokrpour, 2019) and spans many cultures, continents, and civilizations. For over three millennia, saffron was cultivated across the Mediterranean basin, including ancient Greece, Persia, and antique arts and genetic studies demonstrated its origin as cultivated plant in Greece (Kazemi-Shahandashti et al., 2022). Saffron cultivation has a long past also outside the Mediterranean area. In Iran it was already grown in the Zagros and Alvand mountains during the Kingdom of Media (708–550 B.C.) while its presence was testified in India in the third century A.D. by Wan Zhen, a Chinese medical writer. (Cardone et al., 2020). The wild precursor of domesticated saffron crocus proposed by recent research is *Crocus cartwrightianus* Herb., that was selected for plants with abnormally long stigmas by farmers. Thus, sometime in late Bronze Age Crete, a mutant form of *C. cartwrightianus*, *C. sativus*, emerged (Nemati et al., 2019). Saffron was then slowly distributed throughout much of Eurasia, later reaching parts of North Africa, North America, and Oceania.

Today the principal saffron producers are Iran, India, Afghanistan, and China in Asia. There are also some countries producing saffron in Europe, and they are Greece, Spain, Portugal, France, and Italy in the Mediterranean basin (Cardone et al., 2020). The most important exporting countries are however in Asia (Cardone et al., 2020; Fernández, 2004; OEC, 2019). Iran is considered one of the world's leading saffron producers, but it is also one of the countries that use the most groundwater or irrigation water in its cultivation. In fact, in Iran, production cannot happen without at least two irrigation interventions (and four is the number of irrigation interventions recommended) (Koocheki & Seyyedi, 2016). Moreover, the massive production in some regions of Iran can lead to a high degree of mismanagement in farm practices, and a consequent increase in the total greenhouse gas emissions in saffron production (Khanali et al., 2017).

New ways of production more socially and environmentally sustainable are however developing in the main countries of production (Iran). Recent studies are analysing the difficulties and challenges of organic production in this country to implement the conversion to organic agriculture (Veisi et al., 2017; Veisi et al., 2022). Additionally, there are efforts to provide work opportunities for disadvantaged groups as women, reduce the inputs and use small-sized lands, sometimes even occupied by other plants (Shahnoushi et al., 2020). This last occurrence happens also in some other parts of the world as Kashmir valley, where saffron is grown under apple, almond, populus, and walnut plantations, as well as in plains, undulated soils, hills, and rice fields at various altitudes, from 1585 to 2050 m above sea level, and with different agrotechniques. This area is one of the most significant saffron-producing regions of the world, employing about 5% of the total rural workforce in the mentioned valley (Rather et al., 2022). In general, globally, saffron has recently been gaining a more interesting role in low-input agricultural systems and as an alternative crop (Rather et al., 2022). In some countries such as Afghanistan, it is even becoming the tool to fight the cultivation of crops as Opium and promote a more sustainable economic development of some regions as the one of Herat Province (Azimy et al., 2020).

Saffron, however, is also massively produced in India where farmers dry the stigmas by leaving them in the sun for 27–50 h. This drying practice, albeit with low energy consumption, is considered among the main causes that reduce the quality of Indian saffron (Raina et al., 1996).

In many other growing sites of the world saffron is not massively produced and can grow totally without irrigation and following environmentally friendly farming practices, as in most Mediterranean areas. Saffron is produced in different countries in Europe, some of which even became exporters with a little amount of product (Cardone et al., 2020). In Greece, cultivation areas are in Macedonia, in an altitudinal range between 650 and 700 m above sea level, while in Spain, La Mancha, and Castille, saffron is cultivated in areas that occasionally require irrigated conditions (Skrubis et al., 1990).

Italy has a long tradition of saffron cultivation, spanning from Romans to the medieval and modern era (Cardone et al., 2020) and it is one of the main Mediterranean countries producing saffron, albeit in much smaller quantities (450–600 kg per year) than

Iran (>150,000 kg per year) and India (>15,000 kg per year) (OEC, 2019). Italian saffron, usually produced by small-medium farms, proved to be of excellent quality ('first category' according to ISO 3632) in more than 90% of cases (Giupponi et al., 2019) and it is used in many agri-food products, from cheese in the alpine regions to 'pasta' and other dishes in the southern regions (Giorgi & Scheurer, 2015). Until the Second World War this spice was subject to Italian government monopoly, while more recently it was enclosed in the regulation that rules the production and the uses of officinal herbs in general, the Ministerial Decree of 10 August 2018. A less limiting regulation for sure contributed to the diffusion of the cultivation of this spice in recent years.

However, this could be not the main reason for the revival of this crop in Italy. Some more (Cardone et al., 2020) or less (Gresta et al., 2008) up-to-date data on the production of saffron in Italy are provided, but more information on the production practices, the marketing, and the social conditions of this production could be useful for providing findings for further research and the improvement of a socially and environmentally friendly saffron production chain. Information on the technical and economic characteristics of the current Italian saffron supply chain would be useful, at least to understand its sustainability and promote valorization/support actions for this production chain. In fact, the recent agricultural policies move towards the promotion of environmentally friendly farming and the greening of policy incentives (Van Zeijts et al., 2011; Wilson et al., 1999). Particularly, the increase in sustainable food production is a part of the European Green Deal strategy (EC, 2021), and the new EU Common Agricultural Policy (CAP) 2023–2027 objectives stress the pursuit of environmental sustainability in farming activity.

The aim of the research was to analyse the current saffron production chain in Italy through an exploratory study among saffron farmers (including both hobby and professional farmers). In particular, the characteristics of the saffron growers and farms, the agronomic techniques used and the product (and by-products) processing and sale, were investigated.

Data collections

To reach as many as possible saffron growers in Italy, without distinction between hobby growers and professional farmers, the application 'Google Forms' was

used to provide an online questionnaire to a wide set of potential respondents. This solution permitted us to overcome difficulties linked to distance, especially at a time of full pandemic due to SARS-CoV-2. C.R.C. Contacts of potential respondents were gathered starting from two different datasets: (a) the one of Ge.S.Di.Mont. (Centre of Coordinate Research for the Sustainable Development of Mountain Territories), a research centre specialized in realizing of quality certification for saffron growers, and (b) the one of Zafferano Italiano website, a saffron growers' association. Such research was conducted on a list of 550 saffron growers spread all over Italy, to which the online questionnaire was sent. The final version of the questionnaire was confirmed after a pre-testing on a group of 12 growers, to verify the existence of criticalities in filling up the questionnaire. This panel was useful also to verify a maximum time of 15 min to complete it.

The questionnaire was divided into eight sections:

- Section 1 contained the presentation of the project;
- Section 2 was committed to saffron growers' personal features: name and surname (not compulsory), email address (compulsory, to monitor the answer rate and to avoid double answers), age of birth, gender, education level, professional status, years of experience, and so on;
- Section 3 was dedicated to the saffron farms' characteristics: farm location, farm typology, total agricultural area and the area devoted to saffron cultivation, farm labour, and farm products;
- Section 4 gathered data specifically on saffron agronomic practices: crop cycle (annual, pluriannual), origin of corms, planting density, management of field adversities, irrigation, agrochemicals use, mechanization level, and post-harvest practices (drying);
- Section 5 dealt with the economic dimension of saffron growth: saffron prices, market channels, additional processes of transformation, valorization of waste products (especially petals), the use of public grants, and, finally, a question on the recent business development due the pandemic crisis was delivered;
- Section 6 pointed to saffron growers' motivations, issues, and future perspectives;
- Section 7 was focused on the social dimension of saffron growing: participation in a grower association, branding, quality certifications, marketing

aspects, organization of social events related to saffron;

- Section 8, finally, contained details about privacy and acknowledgements.

All questionnaires were collected during 2021, reflecting the situation of the farm at that time. The data so obtained were elaborated through R 3.6.3 software and Microsoft Excel.

Results

Questionnaires collected

One hundred sixty two questionnaires were collected, with a response rate of around 30%, which can be considered a good answer rate for an online interview; the respondents had further a desirable geographical distribution, covering almost all the Italian Peninsula (Figure 1). Making reference to the elevation of saffron cultivations, data are distributed around a median of 330 m a.s.l., while the mean value is 483 ± 466 m a.s.l. The results show that saffron fields are mainly in an altitudinal range between 143 and 703 m a.s.l., which is hilly and submountain areas.

Saffron growers and saffron farms features

The age of respondents spans from 21 to 78 years, with an average age of 46 years (Figure 2(a)). The respondents were then classified as young farmers (under 40 years old – EU, 2022), representing 38% of respondents, and not young (62%) (Figure 2(b)). From this point of view, it is interesting to emphasize that this percentage is significantly higher than the average for Italian farms (only 9.3% have a tenant under 40 years of age, according to data from the 7th Italian National Agricultural Census of 2020). A share of 29% of respondents is female, a figure, in this case, in line with the national average for the agricultural sector (30.7% of the share of female farm holders for the Italian National Agricultural Census data 2020).

For more than half (60%) of the respondents, saffron represents a secondary business, while only 17% of them declared to be professional growers, considering saffron cultivation their principal economic activity. Hobby growers represent 23% of the sample (Figure 3(a)). 72.2% of respondents affirmed to be legally classified as a farm. As easily expected, in this last category the incidence of hobbyists is small. Saffron cultivation is quite a recent activity for

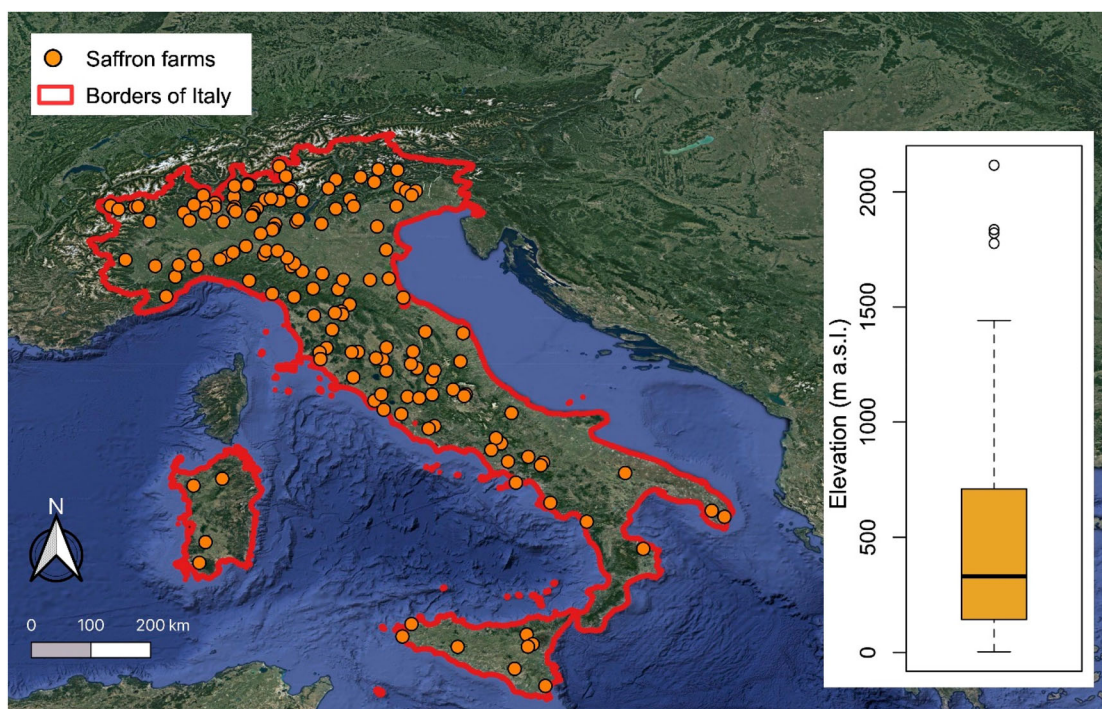


Figure 1. Map of saffron farms which participated in the survey (162) and boxplot of their elevation.

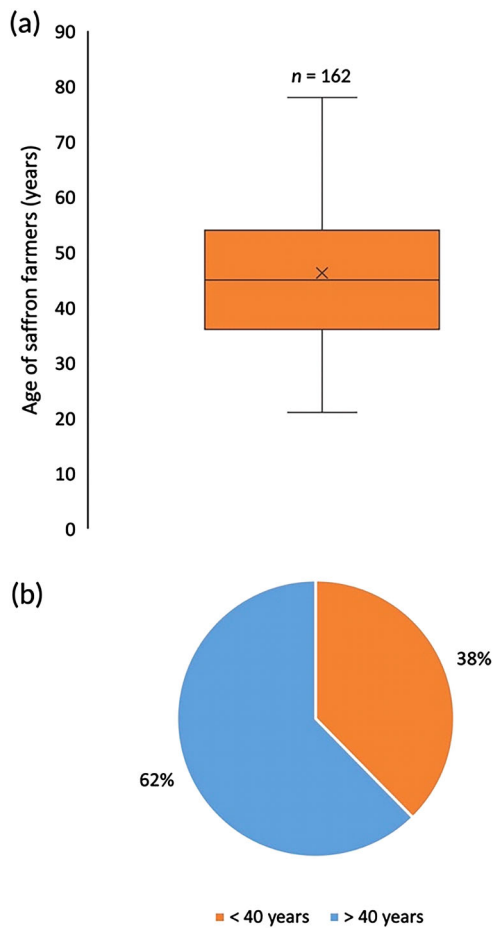


Figure 2. Boxplot of the age of saffron farmers (a) and share of young saffron farmers (aged less than 40 years) (b).

many farmers. In fact, as we can see from Figure 3(b), 48% of interviewed farmers have been growing saffron for less than 5 years, 38% cultivate it for 5–10 years, while only 10% have more than 10 years of experience.

The physical area devoted to saffron cultivation is very limited, and not even remotely comparable to that of the main producing countries. Considering the size of saffron cultivations, 48% of the survey participants cultivate an area of less than 500 m², while 22% cultivated an area between 500 and 1,000 m², and just the 6% cultivated saffron fields bigger than 5000 square meters (Figure 4(a)). The small size of cultivated areas allows their management almost exclusively by using family labour. Only 22% of growers recur to hired labour (5% exclusively and 17% have a mixed workforce). In 17% of cases the cultivation is managed only by one person, while in a higher

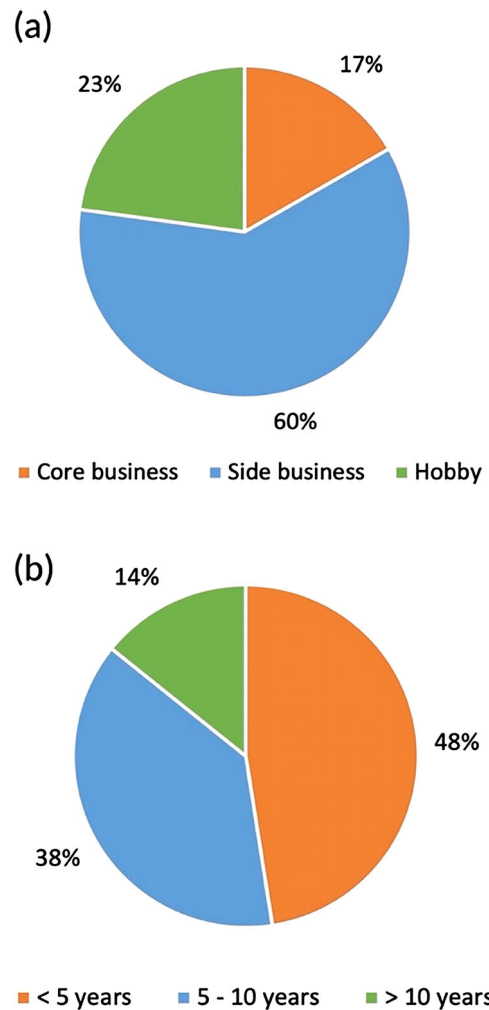


Figure 3. Role of saffron cultivation in the business activity (a) and the number of years of saffron cultivation (b).

percentage (61%), it is an activity involving other members of the farm family (Figure 4(b)). Because of the small dimension of saffron cultivation, saffron production is quantitatively limited. 44% of them produce in fact less than 100 g per year, 26% produce from 100 to 250 g, 17% from 250 to 500 g, 6% from 500 to 1000 g and only 7% produce more than 1000 g per year (Figure 4(c)). The average production of interviewed farmers results to be 332 g per year, with a maximum of 7000 g and a minimum of 2 g.

Intuitively, hobby growers prevail among small cultivations, even if there is a good percentage of hobbyists also in the case of broader areas (especially in the category between 2000 and 10,000 m²). As well, we also observed farmers who consider saffron their

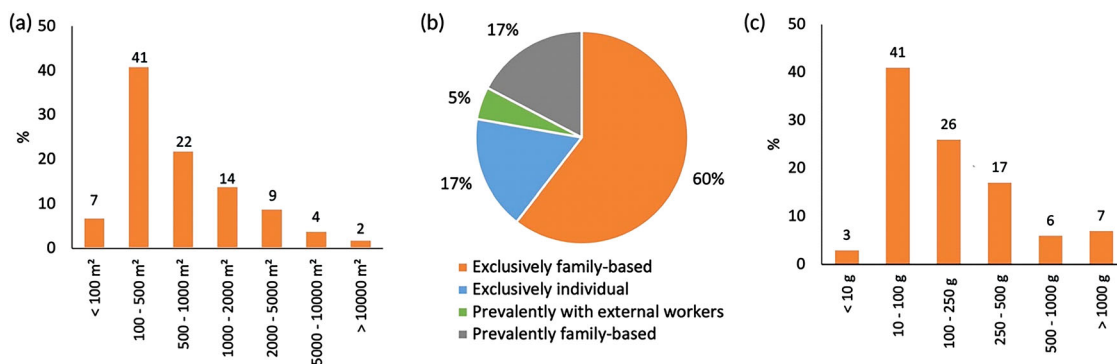


Figure 4. Saffron surface per farm (a), kind of manpower for saffron cultivation (b) and saffron production per farm in 2020 (c). The data are expressed as a percentage of farms.

principal activity also in the case of small-scale fields. However, for the massive cultivations, the category of hobbyist clearly disappears (Figure 5).

Figure 6(a) shows that 38% of respondents are at the higher level of literacy, being graduated (5% also holds a postgraduate education). This rate is impressively higher than the average for Italian farms (only 9.7% in 2020). Interestingly, the share of professional growers (with saffron as a core or a side business) slightly increases with the education level. All respondents with a postgraduate education

consider saffron as a professional activity (Figure 6b). Taking into account only professional growers, we note that only a little share of the university graduates (24.4%) and high school graduates (11.9%) come from an agricultural schooling background. If we compare our data with the national average (Italian Agricultural Census, 2020), 24.1% of Italian farmers reaching a high school diploma education level have an agricultural schooling background, similarly to our results, and 16.1% for university graduates, that is slightly higher than our results.

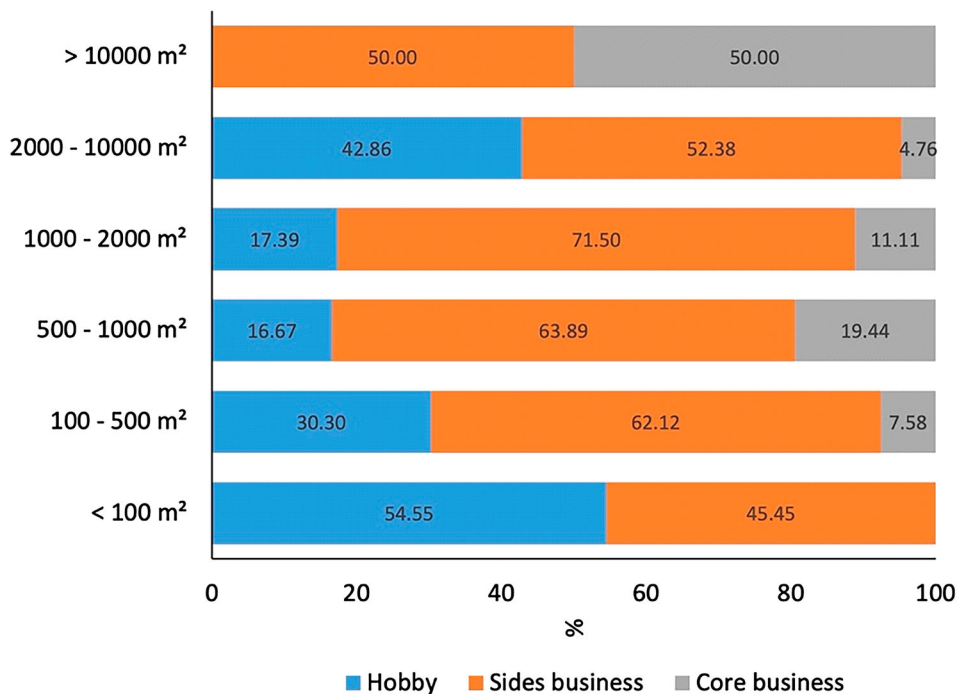


Figure 5. Saffron growers' fields dimension by different professional categories in percentage (hobby vs secondary and principal activity).

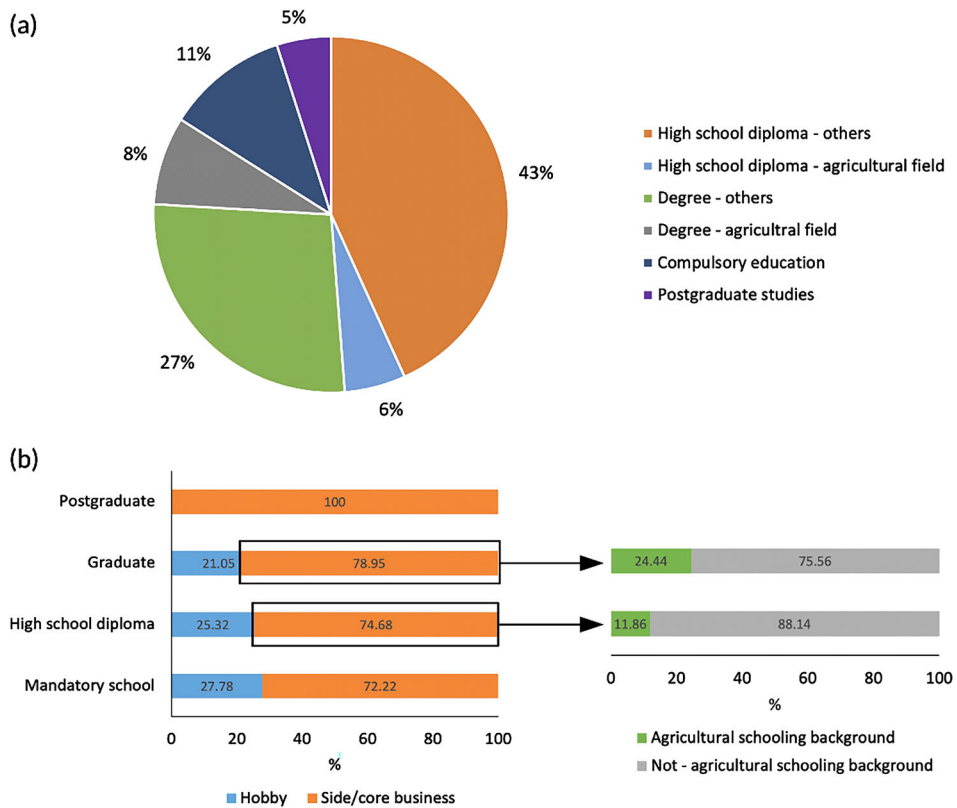


Figure 6. Education level of saffron farmers (a), educational background (education level and agricultural schooling) by different professional category (hobby vs secondary/principal activity) (b).

Agronomic techniques

Most farmers (54%) adopt a multi-year crop cycle, while 27% adopt an annual crop cycle and 20% adopt a mixed crop cycle, both annual and multi-year, in the case for example of farmers who own several plots.

Most saffron growers (90%) who follow a multi-year crop cycle adopt a 2–4 years cycle; in particular, 29% adopt a 2-year crop cycle, 48% adopt a 3-year crop cycle, 13% adopt a 4-year crop cycle and finally the remaining 10% adopt a crop cycle with a duration of more than 4 years. The average duration of the multi-year cycle is 3 years, with a maximum of 7 years and a minimum of 2.

About 65% of interviewed saffron growers plant the corms at a distance between 10 and 15 cm in case of the annual cycle. Instead, where a multi-year cultivation cycle is adopted, usually the corms are planted 15–20 cm distant. These greater distances obviously entail a lower planting density, varying between 15 and 35 bulbs per square meter: 10% adopt a plant density lower than 20 bulbs/m², 30%

use a plant density between 20 and 25 bulbs/m², 26% adopt a plant density between 25 and 30 bulbs/m², 12% use a plant density between 30 and 35 bulbs/m², and 22% of the saffron growers who replied to the questionnaire use a plant density of more than 35 bulbs/m².

Concerning the propagation material, the majority of saffron growers use corms with a diameter greater than or equal to 2.5 cm, only 8% of respondents said they use bulbs with a diameter less than 2.5 cm. 33% of saffron growers use bulbs for planting that have a diameter of 2.5 cm, 24% use bulbs that have an average diameter of 3 cm, and finally 35% use bulbs that have an average diameter of more than 3 cm.

72% of saffron growers interviewed self-produce the propagation material (bulbs), 22% self-produce in part the bulbs, and only 6% of the saffron growers do not self-produce the bulbs. 52% of the producers who buy the propagation material do this to increase the cultivation, about 21% buy bulbs to experiment bulbs of different origins and the

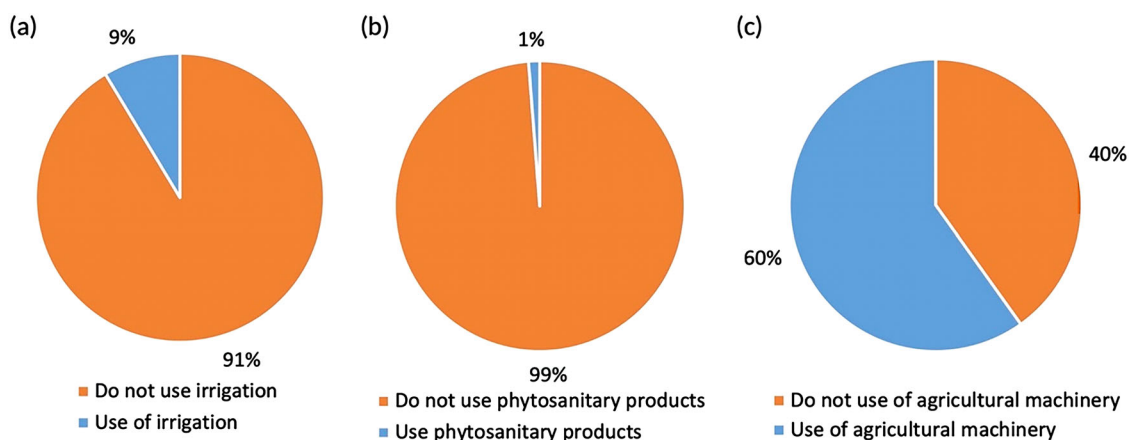


Figure 7. Use of irrigation (a), phytosanitary products (b) and agricultural machinery (c) in saffron cultivation. Data are expressed as a percentage of farms.

remaining 27% buy corms because they have a shortage of self-produced bulbs.

The results show that 70% buy only Italian bulbs, 9% use imported material, and 21% buy bulbs both from Italy and abroad. To date in Italy 32% of saffron growers sell bulbs, while the remaining 68% do not sell them.

Adversities, mechanization and irrigation

The most mentioned issue in saffron cultivation is vole (*Arvicola* spp.), with a percentage of 37%. Then, problems associated with fungi and bacteria (19%), snails (13%), ungulates (deer and wild pigs – 10%), the rest 11% mentioned other sporadic problems as moles, porcupines, hares and some management problems as water logging or weeds. Coherently, most of the Italian saffron growers do not use either irrigation or plant protection products, as shown in Figure 7(a and b). Figure 7(a) shows that 91% of saffron growers who participated in the survey do not use irrigation. Only 1% of respondents said they use phytosanitary products (Figure 7(b)). 60% of saffron growers use agricultural machinery, while the remaining 40% do not use agricultural machinery (Figure 7(c)). These results could appear as a good level of mechanization of saffron growing, but this mechanization mainly concerns soil preparation operations and the mechanical control of weeds, as for other crops (not exclusive of saffron).

Product processing and by-products

Saffron is sold in dried stigmas by almost all the interviewed (57.4% exclusively and 33.3% mainly), while

9.3% of growers mainly process it (Figure 8). Interestingly, nobody declared to sell it in powder, which is the main form of saffron trading in the world. When not sold in the form of stigmas, saffron is mainly processed into food products, spirits, tinctures, herbal products, and nutritional supplements.

Most of saffron growers use an electric drying system to dry saffron (70%) but some other methods are mentioned, for example, the use of hot coals, electric/gas ovens and just a few interviewed saffron growers use the microwave oven. Among the 5% of growers who declare to sell the product transformed, 91% mention alimentary goods, 12% in

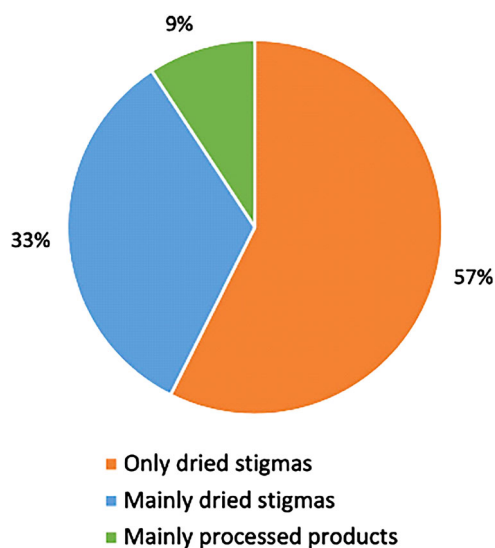


Figure 8. Share of farms selling saffron in stigmas or processed.

cosmetic products, and 10% in nutraceutical/herbal products (for example herbal teas).

The main waste product of saffron production, the tepals, are used as compost in the field by 62% of saffron growers, while 19% of producers manage to repurpose them as dishes decoration, to produce jams, syrups, to give colour to fabrics, for cosmetics and soap, herbal teas, or sell them dry as pastry ingredient or colourant.

The economic dimension of saffron

Considering the geographic extension of the saffron market, from Figure 9(a) we can see how most farmers sell their product in a local market dimension (89.5% of respondents), less in regional or national ones. Very few operate in an international market, and in any case only with small shares of their turnovers. Direct sale to private consumers is accomplished by almost all farmers (92.6%), while about half of them cooperate with food producers/restaurants and traders (respectively 54.9% and 41.4%) (Figure 9(b)). Focusing on direct selling we can observe that the main sales method is on-farm. A good percentage (about 40%) uses web marketing as well (Figure 9(c)).

Almost none of the interviewed sells saffron less than 10 euro/g (Figure 10(a)), while roughly half of them (51%) sell it between 20 and 30 euro/g, 26.6% of saffron growers succeed in selling the products higher than 30 euro/g. The average price of saffron results, then, 23.68 ± 6.95 euro/g with a minimum of 5 euro/g and a maximum of 40 euro/g. Nevertheless, 44% of the interviewed declared the lowest revenue class, 0–1,000 euro (Figure 10(b)), while 31% declared 1000–3000 euro of annual revenue from saffron

cultivation. Only 5.5% of respondents state an annual revenue higher than 20,000 euros. These data confirm the prevalent nature of side-business among Italian saffron growers.

Roughly half of the interviewed (48%) stated that their turnover remained stable in the last five years before 2020, while 39% reported an increase in their business. Nevertheless, about 63% of farmers mentioned a reduction in their sales due to the lockdown determined by the pandemic for Covid-19, when street markets were cancelled and restaurants closed, while the rest succeed in continuing to sell saffron mainly thanks to e-commerce. Of all the respondents, only 4% of saffron growers have benefited from public funding in the past.

The social dimension of saffron

Twenty five percent of the sample declared an affiliation to a saffron producers' association (Figure 11 (a)). Although 93% of farms perform a quality analysis of saffron, only a share of 44% of growers sell certified/quality labelled saffron. Of them 44% obtained the EU Organic Certification (23.7% of the samples, which is a considerable figure compared to the national average of 6.7% of organic farms). Remaining farmers holding a certification, 34% of them have a voluntary quality certification (ISO, EMAS etc.), and 20% have a territorial/collective label. More specifically, the 7% holds the territorial label Protected Origin Denomination (PDO) of the EU (Figure 11(b)). Moving on to marketing aspects, 56% of respondents use a web site to communicate their product, 55% social networks, 51% recur to direct product promotion at farmers' markets, and 35% produce brochures and paper-based materials, 27% through

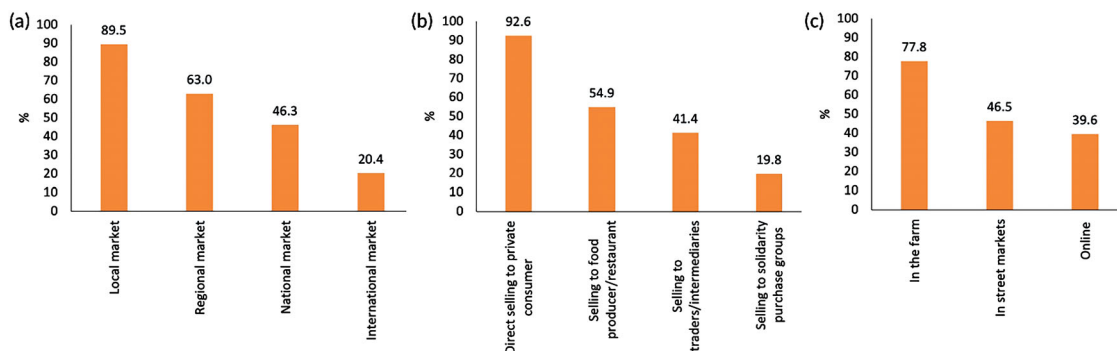


Figure 9. The market area of saffron (a), market typology (b) and sales methods to private consumers (c). The data are expressed as a percentage of saffron farms (a, b) or as a percentage of saffron farms selling to private consumers (c).

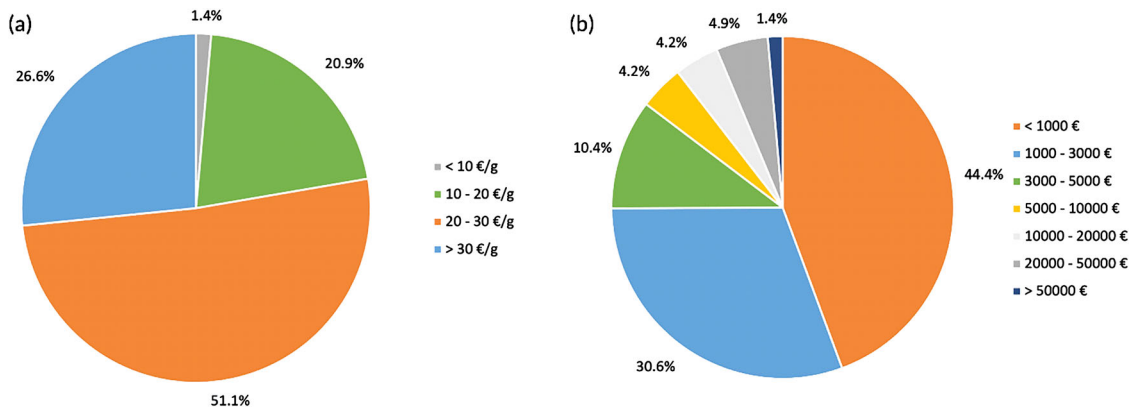


Figure 10. Average price of saffron in EUR/g (a) and the average turnover of saffron per year (b).

direct dialogue at events and trade fairs. Only 30% of farmers organize directly events of promotion. Of them, gastronomic and tasting events are the most mentioned activities (53%) (Figure 11(c)).

Farmers' main motivations, issues, and future perspectives

Saffron production appears a dynamic sector: most of the interviewed declared that their main motivation for taking up saffron cultivation was personal

passion (52%), other to diversify their farm business (23%), 13% for their emotional link with the territory, while only 6% for increasing their income. Half of the respondents declared the intention to increase the cultivated area in the next five years, 63% want to expand the sale channels, while 33% want to introduce new products/services in their business. Technological innovation is seen as a perspective only by 19% of respondents, such as training (18%). Among the factors that have most limited the start-up and growth of saffron cultivation, the main one is

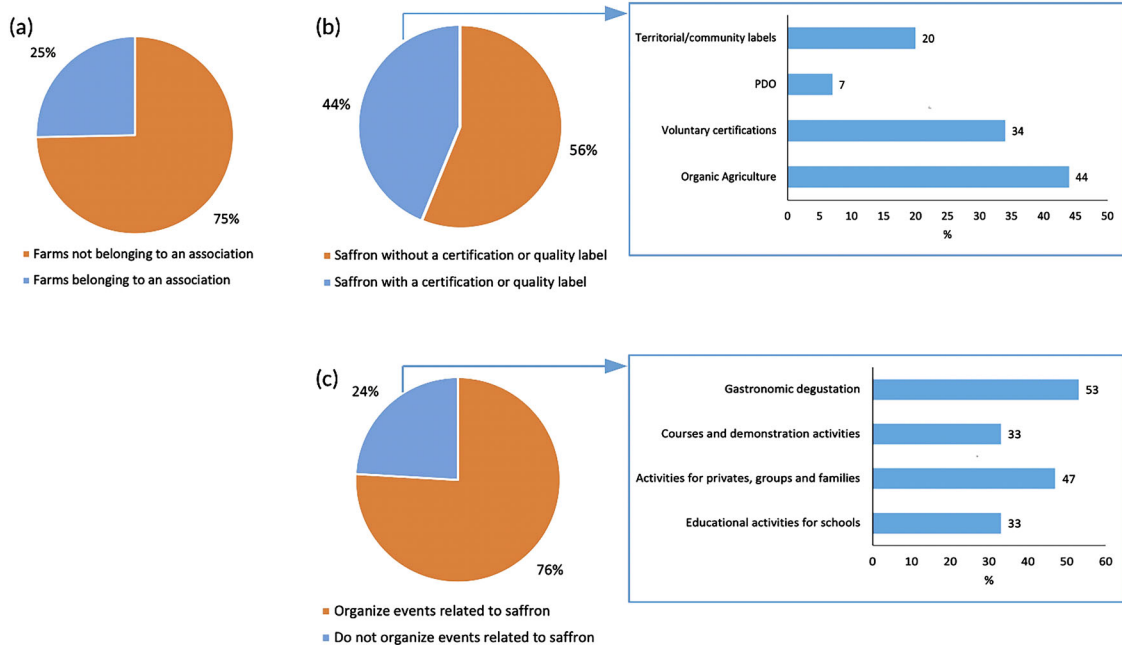


Figure 11. Share of farms belonging to a producers' association (a); farms that have a quality label (b); farms that organize events to promote the product (c).

bureaucracy (24% of respondents). However, 22% of the sample admitted difficulties in product allocation in the market, and 14% declared as the main limiting factor the difficulties in the agronomic management. Other main issues mentioned were shortage of manpower (14%) and land (9%) to increase production. Limited numbers of farmers reported a lack of services for the farms, high cost of propagation material, damages from wildlife, price competition with imported product, and lack of mechanization, especially in the mountain territories.

Discussion

The results of our exploratory study provided some interesting hints on the features of the Italian saffron supply chain. As regards the characteristics of the saffron producers, a relevant percentage (38%) of them are young (aged under 40 years old). Such results are encouraging in a framework where the EU Commission has identified a 'distressing shortage of new farmers' (DGIP, 2012). A shortage of young farmers is a perceived phenomenon, and part of an ongoing debate about the issue of the aging of European farmers and the necessity of generational renewal in agriculture, since young farmers are more likely to conduct profitable and environmentally sustainable farms (Läpple & Van Rensburg, 2011; Lobley et al., 2009; Mann, 2005; Van Passel et al., 2007; Zagata & Sutherland, 2015). Saffron supply chain seems to present a situation far from a shortage of young farmers, a fact that is even more relevant in a country such as Italy, characterized by a high average age of farmers.

Results on saffron growers' educational background are as well interesting. A great percentage has at least a degree or a high school diploma, and some even a master or a PhD, even if not mainly of agricultural background. In marginal areas, such as Apennines or Alpine valleys, people returning to mountains are often new entrants, coming from outside an agricultural background (Gretter et al., 2019). New entrants may provide an entrepreneurialism booster for the agricultural sector (Pindado et al., 2018), and are more prone to environmental protection (Creaney et al., 2023). Knowledge and innovation, especially driven by young farmers and new entrants, are fundamental in modern agricultural systems, where we are seeing a shift toward sustainable agriculture (Pretty, 1998) and the replacement of physical input with knowledge inputs in farm management

(Ward, 1993). In the specific case of Italy, we can also suppose that the shortage of permanent job opportunities due to the financial crisis could lead young people to return to agricultural jobs.

The results of this research highlighted that saffron growing is mainly considered a secondary activity either to other farm activities or to other totally different professions. Saffron cultivation appears to be a good choice for multifunctional farms, and more generally it represents a reliable integration of the farm business (Cardone et al., 2020; Giorgi et al., 2017; Giorgi & Scheurer, 2015; Manzo et al., 2015). Notably, multifunctional agriculture seems to be pursued more by new entrants (Zagata & Sutherland, 2015). Sustainable and especially organic agriculture seems related to farmers who are younger and with less farming experience or are more likely to be new entrants (Padel, 2001). Sutherland et al. (2015) found that new entrants in general (not necessarily young people) were more likely to be involved in high value-added farming activities, thanks to their urban networks and experiences (Sutherland et al., 2015). 48% of interviewed farmers have been growing saffron for less than 5 years, and these results suggest that the saffron growers interviewed were mostly new entrants, and this is coherent within the framework exposed.

Undoubtedly, starting with a small surface is a good choice for new saffron growers and we must also consider that saffron is a very demanding crop in terms of manual labour, and, since saffron cultivation generally has a family business character, is easy to understand that bigger cultivations would require hired labour, greatly reducing profitability margins. As already testified by literature (Giupponi et al., 2019; Gresta et al., 2008) generally saffron fields dimension varies in the range of 200–5000 m², with very few exceptions of fields bigger than a hectare. Our results confirm previous literature data. In fact, 94% of the interviewees have fields smaller than 5000 m² (Figure 4(a)). Furthermore, from Figure 4(c) we can see how the chart of saffron production per farm reflects almost perfectly the one of saffron surface per farm (Figure 4(a)). If the areas cultivated with saffron in Italy are rather small, clearly also the productions per farm are rather limited (mean value: 332 g per year).

Generally, saffron does not represent the core business of interviewed farmers. The share of hobby farmers tends to decrease with the physical dimension of cultivations, on average. However, even

among the smallest farmers, those who consider their business as professional prevail (Figure 5). In this respect, it must be considered that in Italy farms with less than 8000 euros of standard production are 61.4% of total Italian farms (Italian Agricultural Census, 2020).

From our results, we can see that saffron is a plant growing from the sea level to mountain territories and concentrating, in Italy, in foothills areas of Alps and Appennines. Saffron is a crop suitable to grow in marginal areas (Gresta et al., 2008) as foothill and hillside territories, such as abandoned mountain meadows, where we can find soils free from waterlogging, thus becoming a valid tool for the conservation of the territory and the landscape (Giorgi et al., 2017; Manzo et al., 2015).

As far as agronomic cultivation techniques are concerned, our results showed that more than half of farmers adopt a multi-year crop cycle that lasts, in most cases, 2–4 years. The production of saffron declines with the aging of saffron fields, generally after 4–5 years (Sampathu et al., 1984), so the choice of farmers is functional. It's also logical that most of the saffron producers interviewed to self-produce their own bulbs (propagation material). The farmers who cannot self-produce the propagation material (and who buy them off-farm) are probably in areas where there is greater difficulty in producing bulbs of the right calibre (diameter >2 cm), taking into account that the production of appropriately sized bulbs competes with saffron production. For instance, sometimes in the Alps a strong organic fertilization must be done to induce the growth of bulb, but a pushed nitrogen fertilization counteracts the production of the spice, since the plant becomes too rustic (Amiri, 2008). In our sample, the sale of bulbs represents an additional income just for the 32% of farmers. However, the option (for most farmers) to produce their own bulbs, adopting a multi-year cycle, would benefit sustainability. In fact, these practices avoid the importation of bulbs (often from abroad) and reduce soil processing.

Saffron has been already mentioned as a rustic cultivation suitable for low-input farming in marginal territories (Gresta et al., 2008) and this crop was already mentioned as a viable opportunity to diversify agricultural income in multifunctional farms, especially in mountain areas (Cardone et al., 2019). The main challenges reported by the interviewed farmers are ungulates and rodents, which can be managed with zero-impact control strategies, such as using nets or

natural baits (such as broad beans which are more attractive to rodents than saffron). Furthermore, only 1% of respondents declared to use phytosanitary products. Many Italian growers (40%) can manage their activity without the use of machinery since most of the work in saffron cultivation consists of manual labour. These aspects evidence saffron cultivation sustainability and low carbon footprint in Italy, compared with the areas where it is produced massively (Khanali et al., 2017). In addition, just 9% of respondents use irrigation, and this is coherent with the cultivation practices in the Mediterranean area, making Italian saffron more sustainable compared with countries where it surely requires irrigation, such as Iran (Koocheki & Seyyedi, 2016).

The electric dryer is considered an efficient and economic technical solution, allowing the best drying conditions for saffron, in a way that the clean filaments are dry at a temperature not higher than 45–50°C until stigmas can be easily crushed among the fingers. This research confirms that this last process is the most used in Italy and is considered one of the best practices for saffron drying (Giupponi et al., 2019; Raina et al., 1996). Few respondents mention the traditional method of drying near hot charcoal, still in use in some Italian regions such as Umbria and Sardinia. Italian saffron producers also prefer to sell the spice in stigmas entire, as it is a warranty of an unfalsified product. In fact, the saffron powder is more easily adulterated.

The use of petals, the main by-product, is another interesting aspect in the saffron supply chain, considering that the production of cosmetic, herbal products and nutritional supplements is mentioned among our respondents. The flower of *C. sativus* is composed of sepals and tepals (86%), stamens (6%), stigmas and styles (8%) (Hemati, 2010) and during the delicate and labour-intensive manual treatment to clean the stigmas, a large quantity of by-products are produced. In fact, 1 kg of saffron flowers leads to about 63 kg of floral residuals (Serrano-Díaz et al., 2014). This stimulates farmers to make the best use of flowers increasing profits. Saffron has showed large beneficial effects on human health (Finley & Gao, 2017; Shafiee et al., 2018;), as antidepressant, and saffron 'teas' already exist and are produced for example by 'Zafferano Italian Association' (Associazione Zafferano Italiano, 2022). Focusing on tepals (as explained, the main by-product of this value chain) they were found rich in secondary metabolites with demonstrated antioxidant, antibacterial, and

anti-inflammatory activity (Asgarpanah et al., 2013; Baba et al., 2015; Menghini, Bellagamba et al., 2018; Zeka et al., 2015) and other compounds with nutraceutical and cosmetic properties (Cusano et al., 2018; Righi et al., 2015). Consequently, several studies were focused on the possible use of secondary metabolites of saffron tepals as a food supplement or as a component of cosmetic/herbal products (Menghini, Leporini et al., 2018) and the use of all saffron flower components in food and pharmaceutical/herbal industries is open to discussion. The cosmetic employment of *C. sativus* tepals and stamens as skin antiaging agent and decreasing depth and number of wrinkles has been patented (FR2949975-A1; FR2949975-B1; JP2005041811-A; JP4462865-B2).

Saffron market is mainly local, following the logic of short supply chains, characterized by direct contact with consumers increasingly interested in the issues of health food and environmental sustainability (Baldi et al., 2019). Along this line, being in possession of a certification for their product represents a strength for saffron producers. A good percentage (44%) of saffron farmers are in possession of at least a voluntary certification of their product. This is a very positive aspect as more and more producers decide to provide the consumer with a product of the highest quality. Particularly about 24% of the farmers hold the organic agriculture certification. Considering that very few use agrochemicals, this percentage could likely increase. To such extent the research activity becomes fundamental to assist producers in the promotion and improvement of their product, supporting the different aspects of this production, which has important economic implications, but it is also involved in providing socio-cultural and ecosystem services.

It is interesting also to observe how only 4% of growers have applied for public grants. It sounds surprising, especially if we consider that many of them are young and there are potentially specific policy instruments devoted to young farmers, especially within the EU Rural Development policy framework.

Considering the social aspect of saffron, this research shows that 30% of farmers organize social events to promote saffron, and the 25% are affiliated with saffron producers' associations. This last percentage could increase, since associations are also responsible for the promotion of the culture, the properties of the spice and its use in the kitchen, through conferences, seminars, courses, and any other initiative, also collaborating with other

associations promoting niche products such as Slow Food. A survey carried out by the GeSDiMont-UNIMONT centre in 2019 (Leoni, 2020) allowed the detection of 16 saffron producers' associations in 10 Italian regions, very often engaged in activities that go beyond assistance to farmers. In 2020, for example, the PDO Saffron Consortium of L'Aquila (Abruzzo region) organized educational activities for prisoners in the super-security prison of Sulmona, in Abruzzo region and Secondigliano, in Campania. In Piedmont and Trentino regions they promoted the cultivation of saffron to combat recidivism. In some cases, saffron revitalized the ecotourism of a territory, creating an identity around an agricultural product, as in the case of the municipality of Città della Pieve (Umbria region), that built its tourist attractiveness around saffron. The local saffron consortium currently involves about 30 farmers, with cultural and tourist initiatives such as the annual fair 'Zafferiamo'. During the festival, in addition to the gastronomic aspect of the spice and the visit to the saffron fields in bloom, dyeing and painting workshops using this spice are organized. Till now it has been possible to identify 26 'saffron events' in 12 Italian regions. In 15 out of 26 festivals, one of the main events was the organization of a debate, a workshop, or a conference; in 5 cases the event was specifically dedicated to families with children. The topics of the meetings events included: territorial development, wellness-nutrition-health, history and craftsmanship. This cultivation has also a landscape value, testified by the fact that in 12 events related to saffron of the 26 registered at the national level a visit to the saffron fields was scheduled. For instance, the Navelli saffron farmers' cooperative regularly organizes a trekking experience for tourists during the flowering season to visit the fields in Altopiano di Navelli (Abruzzo region) (Leoni, 2020). The strong linkage with the territory, that could be further developed, is well testified also by the 'farmers' main motivations, issues and future perspectives', who mention the linkage with the territory as one of the main reasons for their activity.

Conclusion

This research is an exploratory study that could open numerous possibilities for future investigations. The study provided more information on the characteristics of the Italian saffron supply chain, especially as regards the features of producers, the cultivation methods, and the use of saffron and waste products.

Also, the economic and social dimensions of saffron were taken into account. The production of saffron in Italy is a sustainable agricultural activity, suitable for the recovery and management of marginal territories (hilly and sub-mountain areas), that mainly involve small farms spread throughout the country. Moreover, saffron cultivation proved to be an appealing activity for young and new entrants in agriculture (often at a high level of literacy). Saffron growers in Italy seem to target a niche quality product, voluntarily joining quality and sustainability certifications. In the future, actions to promote this niche production among consumers should be encouraged as well as legislative instruments should be implemented to support producers of such an important food for the Italian gastronomic tradition. Considering instead the field of future research, a deeper investigation of the actual profitability of this activity in Italy and a comparison of the different production regions would be advisable. To increase further the economic, social, and environmental sustainability of this production chain more efforts on applied studies on the use of the by-products would be beneficial in promoting the production of saffron in Italy and other countries adopting a sustainable approach.

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