

SAFFRON (*CROCUS SATIVUS*) AS AN ALTERNATIVE CROP IN SUSTAINABLE AGRICULTURAL SYSTEMS. A REVIEW

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Abstract

Saffron (Crocus sativus) is a bulbous perennial of the iris family Iridaceae. The plant of C. sativus is generally planted for the production of the most valuable part in its flower the stigmas, the commercial name of the dried stigmas being saffron. Crocus plant was considered as 'red gold' and the most expensive spice in the world. This paper aims to pay attention to the world distribution of saffron, its application in various fields and the possibility for its cultivation as an alternative crop in sustainable agricultural systems. The materials used in the research paper cover a wide range of information that credibly cites the authors who reported or referenced the important information about saffron. Available scientific literature enriching information on saffron was used. The collected scientific material is analyzed theoretically, as the article is a review. From antiquity, saffron was widely used as a spice for culinary purposes and food colorant, as well as a dye, preparation of perfumes, preparing tea. In particular, saffron is gaining increasing attention as an alternative crop in sustainable agricultural systems due to its unique biological, physiological, and agronomic traits, such as the capability to exploit marginal land. From an agronomic point of view, saffron is well adapted to different environmental conditions and in recent years a growing interest has been reported in growing saffron in low-cost systems, for example in mountainous regions.

Key words: *Crocus sativus, Saffron, sustainable agriculture*

INTRODUCTION

Crocus sativus is a bulbous perennial of the Iris family (Iridaceae) [41, 16, 56]. The plant of *C. sativus* is generally planted for the production of the most valuable part in its flower - the stigmas [88, 56], the commercial name of the dried stigmas being saffron [47, 97, 102]. The name 'saffron' is derived from the Arabic word *zá-faran*/'Zafaran' [105], which comes from the Persian word 'Zarparan', meaning 'flowers of golden petals' [34]. Crocus is considered the 'red gold' [63, 73, 59, 56, 52] and the most expensive spice in the world [70, 101, 8, 38, 55, 105, 97]. This 'golden' spice is known as 'Kum Kum' and 'Kesar' in Sanskrit, and 'Koung' in Kashmiri language [43, 44, 34]. Its very high price is directly linked to the intensive hand labour required for the daily flower picking, separation of stigmas and drying [36, 37, 96, 95].

This paper aims to pay attention to the world distribution of saffron, its application in various fields and the possibility for its cultivation as an alternative crop in sustainable agricultural systems.

MATERIALS AND METHODS

The review article draws attention to *Crocus sativus*, as a bulbous perennial that is commonly planted to produce the most valuable part in its flower - the stigmas. Its prevalence and wide use in traditional medicine, culinary, etc. are indicated, as well as the main parameters used to determine the quality of saffron, namely colour, flavor and aroma. The materials used in the research paper cover a wide range of information that credibly cites the authors who reported or referenced the important information about saffron. Available scientific literature enriching information on saffron was used. The collected scientific material is analyzed theoretically, as the article is a review.

RESULTS AND DISCUSSIONS

[53] cites [21] who state that over 418 tons/annum of saffron are produced worldwide in areas as follows: in Iran - 108,000 ha, in Afghanistan - 7,557 ha, in India - 3,674 ha, in Greece - 1,000 ha, in Morocco - 850 ha, in Spain - 150 ha, in Italy - 70 ha, and in France - 37 ha. Saffron (*Crocus sativus* L.), is a plant cultivated in various parts of the world, including Iran, China, Spain, Italy, Greece [55, 94, 72, 20, 53], Algeria, Tunisia [15, 81], Azerbaijan, France, Egypt, India, Israel, Mexico, Morocco, Turkey [82, 85, 103, 56], Tibet [16], and Portugal [98]. Saffron is native to Iran and Greece [16]. Iran is the most important saffron producer in the world with a share of 90% of the total production [2, 77, 102, 75, 104, 99] and has the widest cultivation area of saffron covering 47,000 ha, most of which is grown in the Khorasan province [64, 38]. Other locations in Iran, where saffron is grown, are Birjand, Ferdows, Ghaem, Neishbor, and Sahr-Kord. In India it is mainly cultivated in Kashmir and Uttranchal [16] as in the Pampore Karewa of Kashmir saffron cultivation dates back to very ancient times [34]. Saffron cultivation areas are significantly less in Greece (Kozani, Western Macedonia), Azerbaijan (Aspheron peninsula) and Morocco (Taliouine area) [38], Spain (La Mancha), and Italy (Navelli). In Italy there are also small areas of saffron cultivation concentrated mainly in Sardinia (S. Gavino, Cagliari province) and Abruzzo (Altopiano di Navelli, L'Aquila). The authors [30, 31, 38] point out that saffron is also grown on larger areas in France, Turkey, Switzerland, Israel, Pakistan, China, Egypt, United Arab Emirates, and Japan. The Taliouine region in Morocco provides bulbs and saffron, but in recent years there has been a spread to new parts of the country, such as Elhaouz, Oulmes, Boulmen, Chefchaouen, and Midelt [3, 67]. According to Hasan Tahirov - the Chairman of the Bulgarian National Association of Producers of Saffron and Organic Saffron Products, there are 4,750 saffron producers - members of the organization covering an area of about 7,500 dka, which is constantly

growing due to the great interest in saffron. Tahirov points out that the soil and climatic conditions in Bulgaria are favourable for saffron cultivation. In Bulgaria, saffron is grown at an amateur level, and the enthusiasm and aspiration of Bulgarian farmers to grow saffron may be seen in Kardzhali region (village of Oreshnitsa, village of Gluhar); in Haskovo region (village of Golyamo Asenov, village of Slavyanovo, town of Harmanli); in Yambol region (village of Drazhevo); in Shumen region (village of Dobri Voynikov, village of Pristoe); in Silistra region (village of Bradvari, town of Dulovo); in Vratsa region (village of Krushovitsa); and in Sofia region (village of Trudovets).

Saffron is classified into Domain Eukarya, Kingdom Plantae, Phylum Magnoliophyta (Angiosperm), Class Liliopsida (Monocot), Order Asparagales, Family Iridaceae, Genus *Crocus* and Species *C. sativus* [34, 38] point out the biological cycle of saffron described by [7], namely that saffron is an autumn-flowering geophyte that is characterized by a long summer rest, during which the plant survives periods of drought by means of corms. Due to the sterile nature of saffron, the only technique of propagation is classically by daughter corms forming below or on the sides of mother corms; the mother corm thrives only for one growing season and produces 4-5 cormlets; therefore, the rate of propagation is relatively low [99]. [97] cites [27] who state that the annual cycle of saffron involves five major stages: sprouting, flowering, leaf development, development of daughter corms, and dormancy. Saffron is cultivated under various environmental conditions [107]. Saffron cultivation requires explicit climatic conditions with temperatures ranging from not more than 35°C or 40°C in the summer to about -15°C or -20°C in the winter, and can be grown in dry, moderate and continental climate types. It thrives on loamy, sandy, and calcareous soils. Gravelly soil is also excellent for saffron farming, while heavy clay soil is not. Saffron grows best on acidic soil. It thrives well when the soil pH is 5.5 to 8.5 [53].

Rainy autumn, mild winter and warm summer represent the optimal climatic conditions for

this species [28] The monthly minimum and maximum temperatures are the most important variables influencing saffron yield in most of the studied locations [39, 107]. Saffron loves dry hot summers and grows well in climate with annual rainfall ranging from 250 mm to 600 mm. However, in very dry summers it may be necessary for you to water your saffron once - through sprinkling, for stimulation of growth, as rainfalls just before flowering increase the yield. The terrain should be slightly inclined for the water to drain away, as it is preferable to have a sunny terrain facing south. The areas, subject to selection, should be crop-free for the last 3 years as regards crops such as potatoes, carrots, onion, garlic, lucerne, flowers (narcissi, irises, fressias, gladioli), which suffer from the same diseases as saffron, with the best option being for the saffron to be returned to its crop rotation after 10 years. It is recommended to make deep ploughing in the autumn, and to perform preliminary preparation of the soil in April/May. And before planting the bulbs it is preferable to enrich the soil, as proper fertilization significantly increases the yield of saffron [45]. Saffron is a perennial crop (at least 4 to 5 years) that requires sufficient nutrients [64, 53, 39, 8] and due to its low water requirement it occupies a particular position among field crops [64], but realizes very low harvested yield (stigmas/biomass), and in countries with mild and dry climate it is important to improve cultivation in order to increase yields. [53] report that the critical environmental parameters that affect saffron production are altitude, temperature, photoperiod, topographic location [74, 22]; loose, low density, well-irrigated and well-drained clay calcareous soils with an optimum pH range between 6.8- 7.8 [109, 8] cites [14] and [51] indicating that 20-80% of saffron yield is attributed to soil fertility (C/N ratio, available phosphorus, mineral nitrogen and exchangeable potassium). [53] cites [37] indicating the highest flower number and dry stigma yield when planting corms with high density in sandy soil, while obtaining the highest stigma weight on sowing corms in clay soil with high density. Saffron has a

growth length of 220 days, as it needs a mild winter but with enough snow and a dry and hot summer [64]. When plants begin to bloom, harvesting commences quickly, for the flowering period may last only 15 days. The triple stigmas are picked by hand daily just as the flower opens. On drying, either in the sun or by artificial heat, the stigmas lose 80% of their weight. After harvest and when fully dried, saffron must be stored immediately, preferably in tightly covered or sealed tin containers, and protected from light to avoid bleaching. The final product is a compressed, highly aromatic, matted mass of narrow, threadlike dark orange to reddish brown strands about 1 inch long [98].

Saffron is a sterile triploid ($2n = 3x = 24$) plant with a large genome size and a unique source of specific apocarotenoids [31, 99]. The three foremost parameters used to define saffron quality are colour, taste and aroma [100, 23]. [101] cite [13] according to whom saffron is widely used as a food additive for its colour and aroma (taste and smell). The main aroma factor in saffron is safranal, which comprises of about 60% of the volatile components of saffron [92, 42]. Safranal may be partly responsible for the therapeutic effects of saffron, which used to be considered as important factor in traditional treatment of various disorders [78]; [6]; [1]; [31]; [17]. Carotenoids are responsible for the intense colour that saffron provides to aqueous solutions. The main carotenoid of saffron was first isolated by Aschoff in 1818 and was called crocin from the word 'crocos' meaning saffron in German [12].

[94] cites [106], according to whom phytochemical studies of saffron have shown that the main chemicals responsible for its color are crocins, which are a series of mono and diglucosyl esters of crocetin, a polyene dicarboxylic acid (8,8-diapocarotene-8,8-dioic acid). Further secondary metabolites include flavonoids (mainly glycosidic derivatives of kaempferol), mangicrocin, an unusual xanthone-carotenoid glycosidic derivative, and picrocrocin, namely 4-(β -D-glucopyranosyl)-2,6,6-trimethyl-1-cyclohexene-1-carboxaldehyde, this last responsible for the bitter taste of the spice

[96]. [102] reports that in order for the stigmas of *C. sativus* L. to turn into a spice, a dehydration process is necessary and according to [24] drying causes changes in the physical, biochemical and chemical properties of saffron. [61] reports that the quality of saffron is determined in accordance with ISO 3632 (2003), and depending on the physical and chemical characteristics saffron is classified into three categories. One stigma of saffron weighs about 2 mg and each flower has three stigmata; 150,000 to 200,000 flowers must be carefully picked one by one to obtain 1 kg of spice [72] and about 400 hours of work [67]. Saffron-growing in Spain has been world-wide referenced both in yield and quality; the spice produced in the region of Castilla-La Mancha, Spain is globally recognized as being of the best quality [23, 59]. Among the varieties, the most hard to find on the market is the saffron coming from the Indo-Pakistani area of Kashmir, which produces the darkest variety in the world that tends towards a purple-brown colour, called Mongra or Lacha. The small Italian village of Zafferana Etnea, Sicily produces a very rare variety of saffron, and the most precious saffron in the country comes from the valleys close to the city of L'Aquila in Abruzzo [33]. For a long time, saffron has been neglected by researchers and farmers since it was considered a minor crop used only for agricultural diversification [38]. Nowadays, the interest in it is increasing due to its applications in industry viz., the textile, dye, drug and culinary adjunct, coloring, and flavoring industries; furthermore, it has also gained interest for its pharmacological properties [65, 66, 53]. Its other advantages are the higher cost and lower water needs [99]. In recent years, saffron cultivation has assumed a more important role in low-energy agricultural systems, such as the organic farming system [68]. In particular, saffron is gaining increasing attention as an alternative crop in sustainable agricultural systems due to its unique biological, physiological and agronomic traits, such as the capability to exploit marginal land [50]. Saffron is cultivated in a wide range of environments [38] and from an agronomic point of view it is

well adapted to a variety of environmental conditions from dry subtropical to continental climates [11, 60, 64, 50, 96, 57]. There is a growing interest in applying low-input cropping systems (e.g. saffron cultivation) in mountain regions. Saffron may be also cultivated under semi-mountain and mountain conditions [48]. Climate change has become the biggest threat to Nature and humanity with data showing that the 15 hottest years on Earth on record occurred in the last 20 years. In Bulgaria we witness increasingly longer periods of drying up [25]. It is expected that by the end of the XXI century there will be a decrease in Bulgaria of the average annual precipitation of 5- 10 to 15- 20%, reaching its highest point in the summer and in South East Bulgaria [5]. The growing impact of the Azores (tropical) anticyclone on the temper of weather already affects even the winter weather in Bulgaria with a tendency towards more snowless and warm winters [62]. The expected significant increase of the frequency of dry periods in Bulgaria requires purposeful and reasonable measures as regards the rational use of water resources, as well as the adaptation of the agricultural profile towards more dry-resistant and drought-loving crops [26]. Climate change, which is the result of the global trend of temperature increase, may create an opportunity to cultivate the crop saffron in regions, which already have the necessary climatic specifics, namely soft and low temperatures, respectively during the day and at night. The climate to the south of the Balkan Mountains become increasingly Mediterranean [25].

There is also an assumption that climatic changes in Italy and Spain will affect the reduction of their production, and that in the next 40 years the Balkans will prove to be the most favorable place for the cultivation of this crop [46].

Saffron is becoming a "modern" crop on alternative farms in Bulgaria, following attempts to redirect tobacco production [71]. There are scientific publications on saffron in literature covering its biology [19, 37], history [55], origin [18, 57], chemical composition [78, 54, 105, 19], distribution and production [29], cultivation [89], harvesting, processing,

yield [90], and uses [68]. In Antiquity saffron was widely used as a spice for culinary purposes and a food colorant, as well as a dye [40, 41, 42], for preparing tea, perfumes [16], cosmetics preparation [13, 38], incense sticks. Its health management properties was discussed in traditional prescriptions, including Chinese, Ayurveda and Unani medicines [76]. Especially recently, saffron has been used as a natural colorant instead of synthetic colorants [9]. In recent years, the use of saffron in food applications has been steadily increasing, despite its high price, because of changes in consumer preference toward natural products. The stigmas of *C. sativus* Linn. are used as coloring and flavoring agents in the preparation of food in different parts of the world. Saffron stigmas have a pleasant bitter and somewhat warming taste [16]. True saffron has a pleasantly spicy, pungent, bitter taste and a tenacious odor. Besides being steeped in tea, it is used for seasoning many foods, such as fancy rolls and biscuits, rice. It is a highly prized spice used for both sweet and savory dishes, most notably Italian risotto, Spanish paella, and many Iranian and Asian recipes [97]. Saffron is used as a spice on fish products, meat, pastry, cooked rice, soups, cheeses, lemonades, food sauces [10]. In Sicily, the interest in this crop is even greater and particular, as it is involved in the production of the traditional 'Piacentinu Ennese' cheese, the taste, colour and aroma of which are strongly influenced by this spice [96]. It is possible to buy wines aromatized with saffron, as well as many liqueurs, comprising vodka and gin, which are renowned for their digestive properties [33].

Herbal/natural products represent one of the most common forms of complementary and alternative medicines [94, 69, 108]. The stigmas of the plant are mainly used for therapeutic purposes [79, 16]. In Persian traditional medicine, it is used for treatment of depression [76, 58] quotes the authors [32] who point out that the dried stigmata of *Crocus sativus* L. have been used in traditional medicine against spasms, bronchospasm, menstruation disorders, liver disease, pain, insomnia, digestive ailments

and as a stimulant, aphrodisiac, antidepressant and for supportive treatment of cancer [91]. [82] point out that according to the authors [86, 83, 84] saffron and its ingredients have hypolipidemic, anti-inflammatory, antioxidant and anticancer effects [110], moreover, this is applicable for the treatment of asthma.

[72] and [78] adds that the stigmata of saffron are also used in folk medicine as an anticatarrhal, eupeptic, antispasmodic, expectorant, emmenagogue and nerve sedative. [8] reports authors [87, 105] indicating that the stigmata of saffron have been used as a sedative and analgesic in traditional medicinal preparations. [76] cite authors [35], according to whom *Crocus sativus* has a role as an expectorant, anti-asthma agent. [93] and [80] adds that saffron is used to treat coughs, whooping cough, atherosclerosis, intestinal gas, Alzheimer's disease and dry skin. [50] reports that according to authors [40, 49, 4] this herb has many pharmacological properties, such as anti-inflammatory, antioxidant, anti-tumor and anti-depressant effects.

CONCLUSIONS

Saffron (*Crocus sativus* L.) is a plant that is cultivated in different parts of the world and that is gaining increasing attention as an alternative crop in sustainable agricultural systems due to its unique biological, physiological and agronomic characteristics. From an agronomic point of view, saffron is well adapted to different environmental conditions and in recent years a growing interest has been reported in growing saffron in low-cost systems, for example in mountainous regions.

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